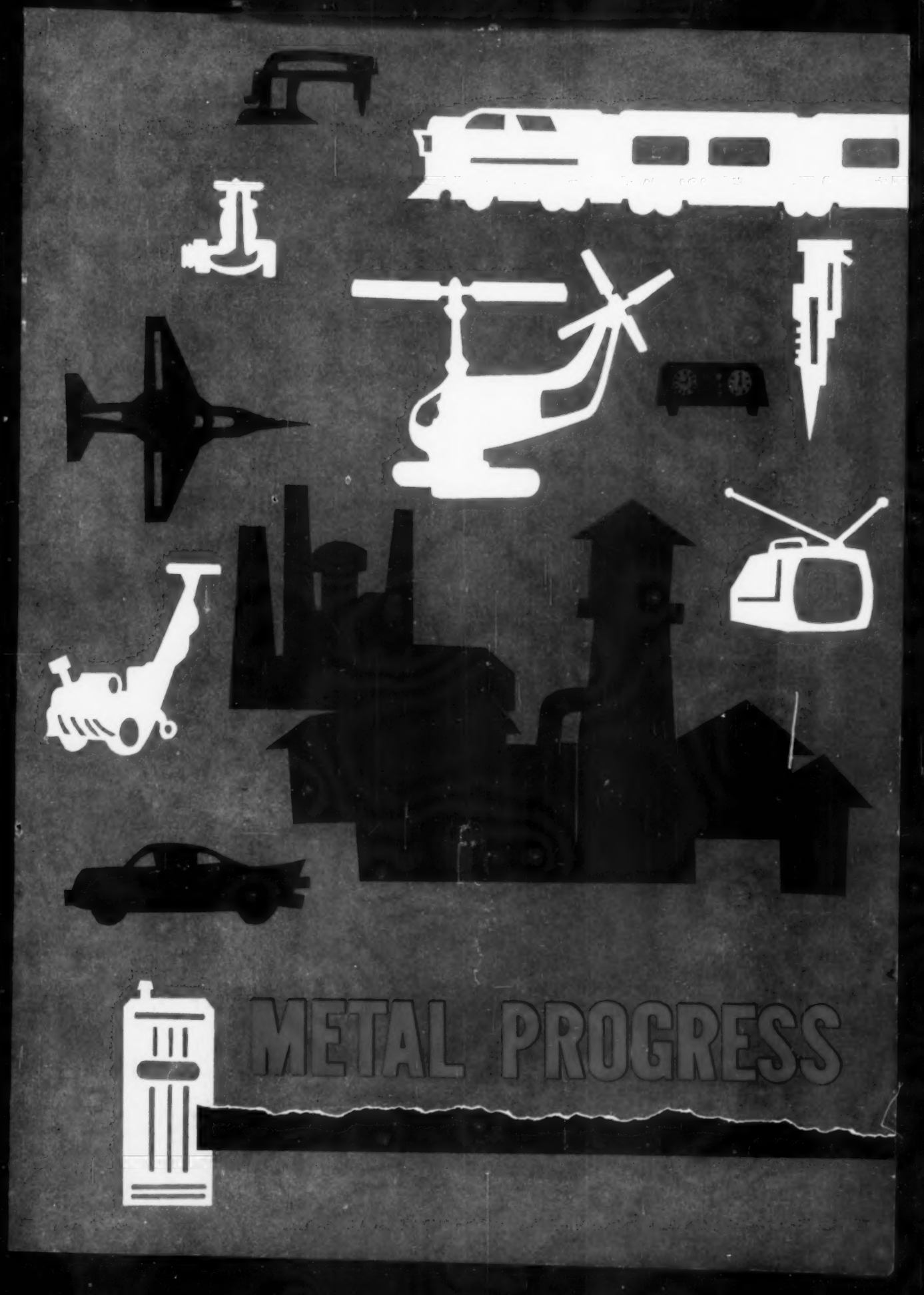
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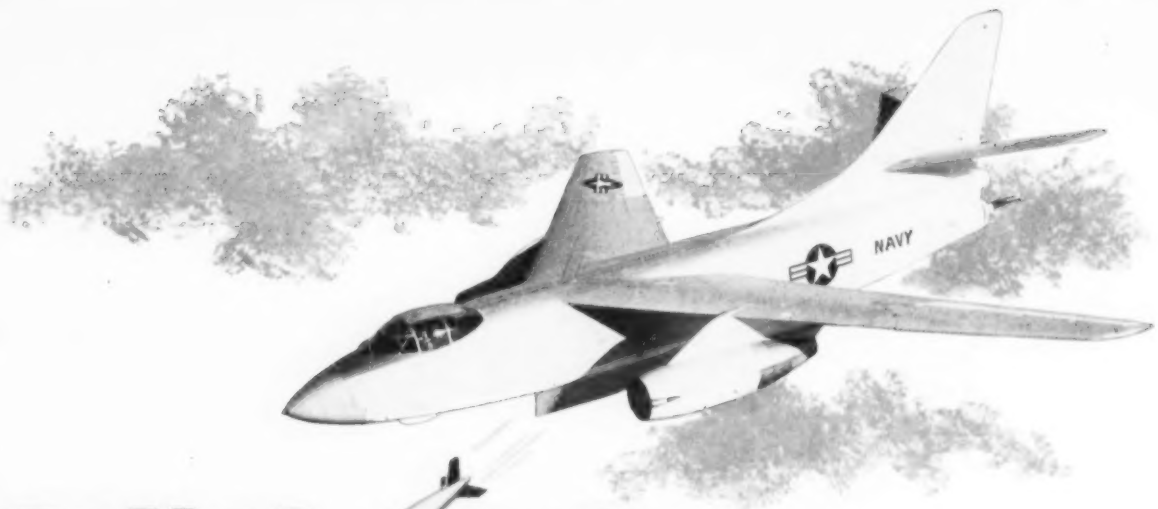


BOMBS AWAY...

with the help of heat-treated TITANIUM ALLOY

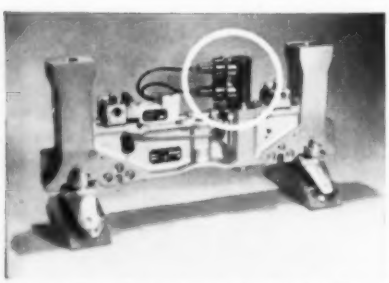
On high speed military planes, such as the Douglas A3D-2 Skywarrior and other jet aircraft, the bomb ejector rack is a complicated and critical mechanism. Any failure might endanger both airplane and pilot.

Three basic parts make up the ejector . . . cylinder, piston and breech. The latter presented the greatest design problem, due to its multitude of functions and irregular shape. Similar breeches made from stainless steel frequently heat-checked and failed, during test firing or hydrostatic testing.

Experience and design calculations suggested that 6Al-4V titanium alloy, produced by Mallory-Sharon, was the metal most likely to meet the exacting requirements.

Actual firing tests confirmed the advantages of titanium for this application. The titanium alloy breech withstood 300 firings before any evidence of heat checking appeared. No failures occurred in firing . . . and the breech withstood hydrostatic pressure of 27,000 psi without failure.

Here's one more example of titanium's outstanding performance in meeting critical design problems. May we help you explore its advantages for *your* product or application? Write for "Titanium Fact File".



Above: Bomb ejector rack, showing forged titanium alloy breech (circled).

Below: Titanium alloy ejector breech, before and after machining.

WHY TITANIUM WAS CHOSEN

1. High strength-to-weight ratio at elevated temperatures for short times.
2. Superior corrosion and erosion resistance.
3. Excellent forgeability.
4. Good machineability in the heat-treated condition.
5. Low susceptibility to hydrogen embrittlement.
6. Good thermal stability.

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Metal Progress

October 1958 . . . Volume 74, No. 4

Cover, by DOMINICK FALSO, student at Cleveland Institute of Art, typifies the wide variety of metal products and operations that will be seen and discussed at the Cleveland Metal Show.

National Metal Congress and Exposition

Invitation 65

Technical Programs 66

For eight days, Saturday through Saturday (Oct. 25 through Nov. 1), visitors to the Metal Congress will have a wide choice of metallurgical education and technology in sessions presented by the American Society for Metals, the Metallurgical Society of A.I.M.E., Society for Nondestructive Testing, Industrial Heating Equipment Association, Metals Division of Special Libraries Association, Metal Treating Institute, and Metal Powder Industries Federation.

National Metal Exposition 89

List of exhibitors, booth numbers and brief descriptions of products.

Engineering Articles

Preview of Space Metals, Staff Report 96

Paralleling the requirement for new materials for aircraft, missiles and satellites is the need to develop improved capabilities in the common metal systems. Here's a report on where we stand and future prospects in . . . Aluminum . . . Magnesium . . . Steels . . . Titanium . . . Beryllium . . . Superalloys . . . Refractory Metals . . . Ceramics and Cermets . . . Graphite . . . Composite Materials . . . Sandwich Construction . . . Surface Treatment and Coatings . . . (T24, 17-57)*

What's New in Everyday Uses for Metals

Aluminum . . . Wrought Alloys, by J. A. Nock, Jr. and F. Keller 114
Stainless Steels, by Richard E. Paret 116
Ferrous Castings, by Thomas E. Eagan 118
Steels . . . Alloy and Carbon, by E. W. Husemann 120
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Nonferrous Castings, by D. L. Colwell 127
Cast High Alloys, by E. A. Schoefer 129

Detroit Revisited — Appraisal of Recent Metallurgical Advances in American Automobile Manufacturing, by J. L. McCloud 130

Among the recent changes and those soon to come in materials for automotive use, the trends toward low-alloy and carbon steels and toward greater use of aluminum seem the most significant. (T21, 17-57)

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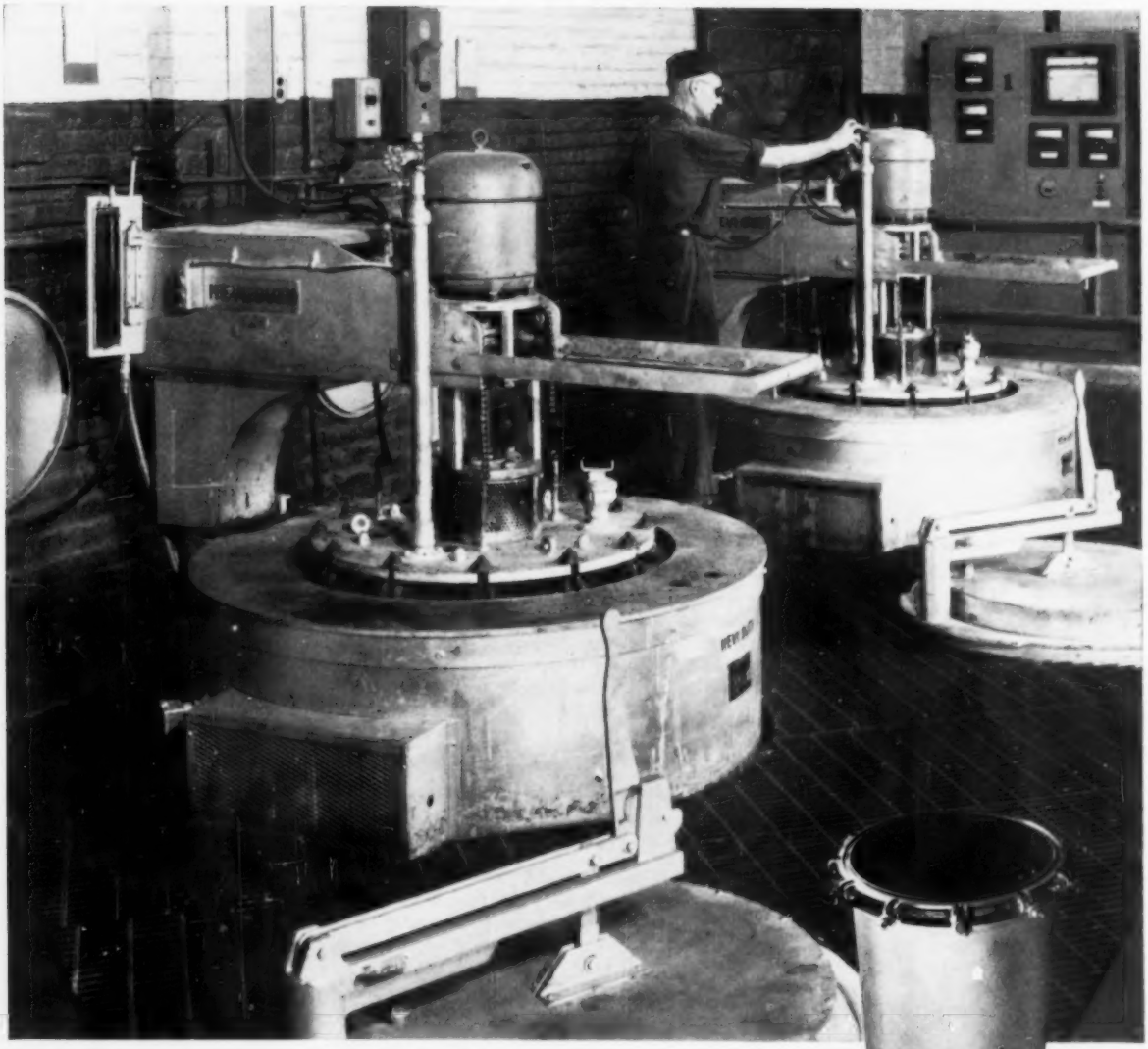

Carburizer-Nitrider furnaces manufactured by Hevi-Duty Electric Company.
See this retort at Booth 215, National Metal Exposition, Cleveland, October 27-31.

In high-temperature carburizing – Thermalloy* centrifugally cast retorts last longer!

The special requirements of the new high-temperature carburizing process demand retorts of superior heat-resisting qualities . . . qualities inherent in Thermalloy centrifugally cast alloys.

"The greater density of centrifugally cast alloy retorts provides superior strength at high temperatures, thus increasing the anticipated life of the retort when used for high-temperature carburizing," says Arthur Frank, V. P., Engineering, at Hevi-Duty Electric Company. Hevi-Duty is a leading maker of electric heat-treating furnaces and a pioneer in high-temperature carburizing.

If you are using or intend to use the new process, be sure your retorts will stand up. Use Thermalloy centrifugally cast, heat-resistant alloy retorts. *Reg. U. S. Pat. Off.

American Brake Shoe Company

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

Metal Progress

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Potential of Higher Temperature Carburizing, Staff Report 134

Manufacturers are becoming interested in carburizing at higher temperatures as a means for increasing production. First moves by heat treaters will probably be to the 1800 to 1850° F. range which will give carburizing rates about 50% higher than are obtained at 1700° F. Even higher temperatures may be used in the near future for thick cases on tractor gears and other heavy-duty equipment. Furnace problems appear to be solved but other problems must be considered in the heat treating and steelmaking areas. (J28g, 1-66, W27; ST)

Special Feature on Better Metallographic Techniques

Metallography of Disturbed Uranium Surfaces, by H. P. Roth and R. B. Russell 140

Shows how micro-examination and X-ray diffraction may work together to provide information leading to sound judgments in physical metallurgy. (M21, M22g; U)

Polishing Hard Metals Electromechanically, by J. M. Dickinson 142

A new technique simplifies metallographic preparation of high-melting metals and their alloys. By simultaneous use of mechanical and electrolytic polishing, layers of worked metal are avoided, and an exceptionally smooth surface is produced in a short time. (M20p; SGA-q)

Polishing by Vibration, by E. L. Long and R. J. Gray 145

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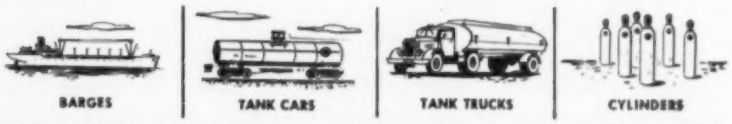

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EASY-FLO 45		45	15	16	(24% Cd.)	1125	1145	4.92
EASY-FLO 35		35	26	21	(18% Cd.)	1125	1295	4.90
SIL-FOS		15	80	—	(5% P.)	1185	1300	4.45
SIL-FOS 5		5	88.75	—	(6.25% P.)	1185	1300	4.37
NEW NAME	**FORMER NAME**	**SILVER**	**COPPER**	**ZINC**		**MELTING POINT °F**	**FLOW POINT °F**	**TROY OUNCES PER CU. IN.**
BRAZE TEC*	TEC*	5	—	—	(95% Cd.)	640	740	4.60
" 056*	TEC-Z*	5	—	16.6	(78.4% Cd.)	480	600	4.53
" 071	SN #7	7	85	—	(8% Sn.)	1225	1805	4.82
" TL	TL	9	53	38		1410	1565	4.50
" 202	AT SPECIAL	20	45	35		1315	1500	4.68
" ATT	ATT	20	45	30	(5% Cd.)	1140	1500	4.64
" NE	NE	25	52½	22½		1250	1575	4.71
" 251	AE	25	57.5	17.5		1255	1625	4.68
" SS	SS	40	30	28	(2% Ni.)	1220	1435	4.76
" 404	SS-5	40	30	25	(5% Ni.)	1220	1580	4.72
" DT	DT	40	36	24		1235	1415	4.80
" DE	DE	45	30	25		1230	1370	4.82
" ETX	ETX	50	34	16		1250	1425	4.99
" 541	ALLOY-4772	54	40	5	(1% Ni.)	1340	1575	5.06
" 560	ER	56	22	17	(5% Sn.)	1145	1205	5.00
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" RT	RT	60	25	15		1245	1325	5.02
" 603	RT-SN	60	30	—	(10% Sn.)	1115	1325	5.23
" 630	RSNI	63	28.5	—	(6% Sn.- 2.5% Ni.)	1275	1475	5.12
" EASY	EASY	65	20	15		1235	1325	5.06
" MEDIUM	MEDIUM	70	20	10		1275	1360	5.14
" BT	BT	72	28	—		1435	1435	5.24
" HARD	HARD	75	22	3		1365	1450	5.28
" 752	TR #1	75	—	25		1300	1330	5.06
" IT	IT	80	16	4		1345	1490	5.29
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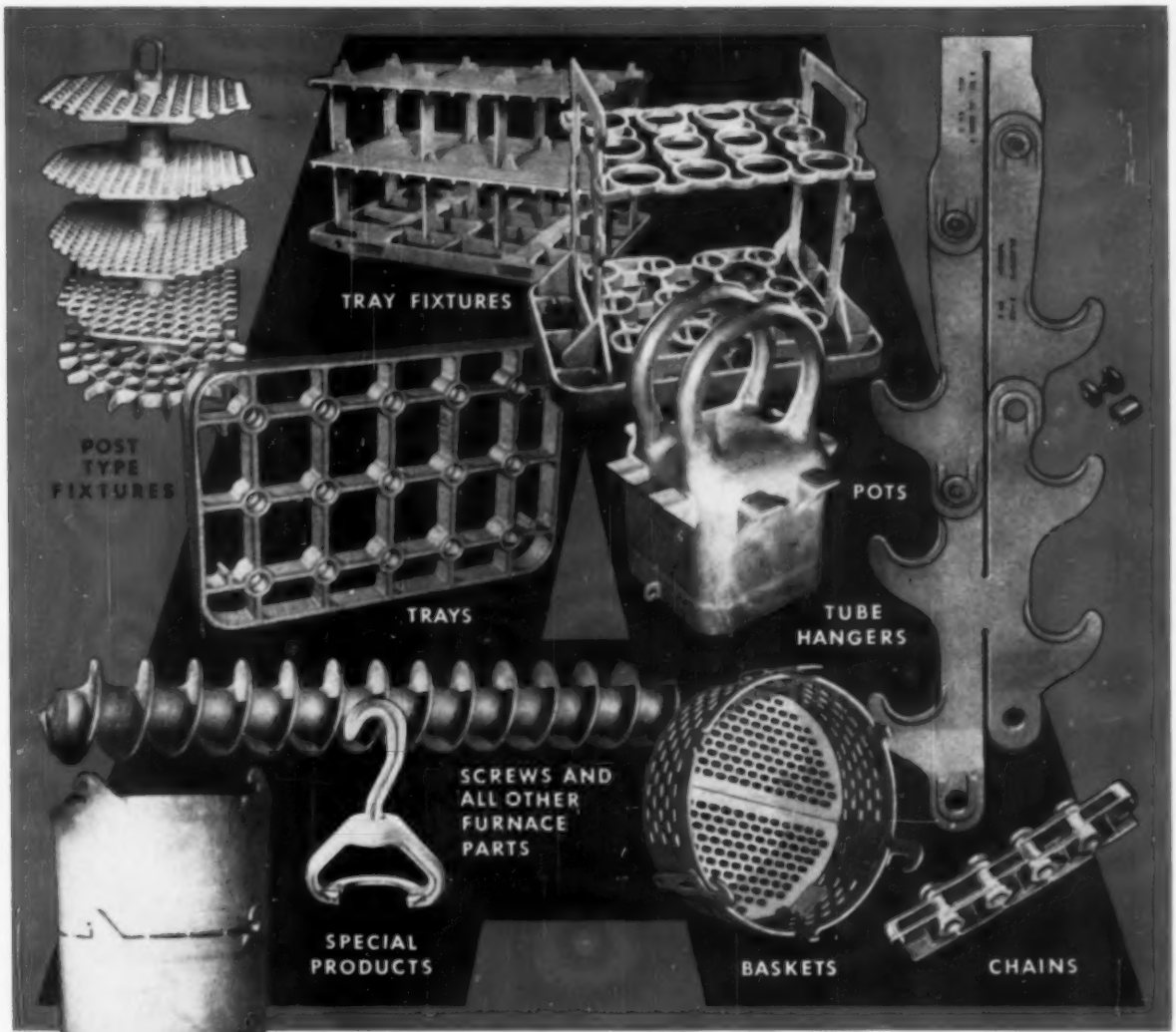

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STAINLESS STEEL CASTINGS

AEC ENGINEERING GIVES Better Service ON HIGH TEMPERATURE TOOLING

"Custom Engineered" PRODUCTS FOR ALL HEAT TREATING and OTHER HIGH TEMPERATURE OPERATIONS

ENGINEERING MAKES THE DIFFERENCE

The examples shown—and hundreds of others—have all given superior service. High integrity products are assured by component design, by use of proprietary casting technology, and in preferred metallurgical structure in relation to service stresses. Production utility is assured by our unequalled background on high temperature mechanisms and in heat treating processes.

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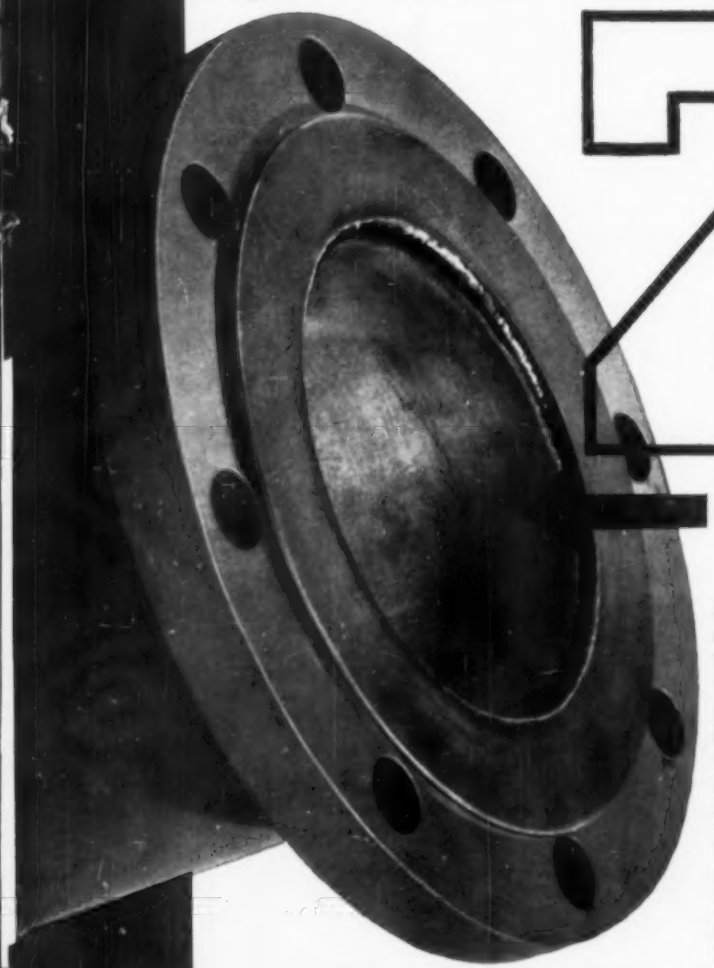
"MORE Zr FACTS"... a publication devoted to progress in zirconium technology is distributed free of cost by Carborundum Metals.

Ask to be placed on the mailing list... the next issue will concentrate on Zr Nuclear Properties and Applications.

fights corrosion with economy



Zr

on the inside

(mild steel on the outside)

Zirconium liners are now available for a variety of basic processing components such as "T's", columns, tanks and reaction vessels. These liners provide all the versatile corrosion-resistance and outstanding nuclear properties of zirconium at surprisingly low cost. Rapid advances in zirconium manufacturing and fabrication techniques offer greater savings for:

THE NUCLEAR INDUSTRY

Zirconium's low neutron absorption and corrosion-resistance to coolants permits more economical fuel applications in almost every reactor design.

THE CHEMICAL PROCESSING INDUSTRY

Dual resistance to corrosion...zirconium protects against either strong acids or caustics. Versatility means interchangeability and longer lasting system components.

Carborundum Metals' fully integrated zirconium facilities and its close working relations with leading fabricators gives you *one* experienced source for every need in zirconium...from sponge metal to ready-for-service components. Firm quotations and delivery dates can be made immediately on commercial or nuclear grade sponge and ingot, and also on welded or seamless zirconium tubing, zirconium sheet, strip, bar, rod and foil.

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THE CARBORUNDUM METALS COMPANY, Akron, N.Y.
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Production Pioneer of ZIRCONIUM

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91-807

Castings of

ARMASTEEL®

so tough they replace forgings
so machinable...they reduce
finishing costs

CLASSIFICATION	CHARACTERISTICS	HARDNESS (BHN)	MIN. TENSILE STRENGTH (PSI)	MIN. YIELD STRENGTH (PSI)	MIN. % ELONGATION IN 2 INCHES
ARMASTEEL GM 86M	Recommended for less highly stressed parts. Replaces steel parts in 1020-1035 S.A.E. range.	163-207	70,000	48,000	4.0
ARMASTEEL GM 85M	Recommended for moderate strength plus adaptability to selective hardening. Replaces parts in 1035-1050 S.A.E. range.	197-241	80,000	60,000	3.0
ARMASTEEL GM 84M	Recommended for high degree of strength. Replaces heat-treated parts in 1040-1050 S.A.E. range.	241-269	100,000	80,000	2.0
ARMASTEEL GM 88M	High resistance to wear and high yield strength, yet retains machinability. Requires no heat-treating and possesses same strength and wear characteristics as alloy steel forgings.	269-302	105,000	85,000	2.0

CENTRAL FOUNDRY DIVISION

Because ARMASTEEL castings are so machinable, so resistant to wear and shock, and so adaptable to selective hardening, they are rapidly replacing many parts formerly machined from bar stock or steel forgings.

ARMASTEEL, a pearlitic malleable iron, possesses the same strength and performance characteristics usually associated with plain carbon steel. In addition, ARMASTEEL contains excellent bearing properties, has high yield strength, good damping capacity, maximum rigidity and excellent fatigue life. Accurate control of heat-treating operations in the manufacture of ARMASTEEL produces a fine, uniform grain structure and provides excellent finishing qualities.

Four different types of ARMASTEEL can be cast to your specifications. One of the four (GM 84M, GM 85M, GM 86M or GM 88M) will have the physical properties to best meet the requirements of your application. For example, ARMASTEEL castings are being successfully used in the automotive, appliance and implement fields for such parts as gears, pistons, crankshafts, rocker arms and universal joint yokes, all of which utilize to best advantage the outstanding characteristics of ARMASTEEL.

Some of these applications are shown in the table. Look them over carefully; you may find that these characteristics and advantages of ARMASTEEL can help reduce your costs . . . increase your production . . . and improve the performance of your products.

Typical ARMASTEEL castings

Because of the greater physical properties of GM 86M ARMASTEEL, it was possible to redesign this anchor plate as shown and effect a weight reduction from 2.26# per piece to 1.44# per piece.

GM 86M ARMASTEEL provides the ideal casting for this automobile differential case because of its high strength, minimum deflection and good damping qualities which contribute to quietness of operation. Note the as-cast internal cavity and the well-formed webs.

GM 85M ARMASTEEL provides a crankshaft with more desirable machining characteristics than a forged crankshaft of SAE 1045 steel. Improves machining of journals and reduces checking stock. Use of GM 85M ARMASTEEL made possible the redesign of the crankshaft with a resulting 3.5# weight reduction and a lower material cost.

By converting to GM 85M ARMASTEEL, drilling and boring operations were eliminated on this crankshaft sprocket. Stock in rough part was reduced from 1.93# in forging to 1.00# in casting. Customer realized reduced piece price with GM 85M ARMASTEEL.

GM 84M ARMASTEEL was specified for this socket plate journal because its microstructure makes it more easily machined than steel with the same physical properties. It has better bearing and wear resistance qualities . . . less distortion during machining . . . and does not require heat treatment. Weight of part in rough is less than comparable steel forging.

Crankshaft for newly designed small gasoline engine. GM 84M ARMASTEEL specified because of outstanding success in similar engines. Less stock removal and better machinability are advantages over forged crankshaft.

This planet gear carrier was formerly forged from SAE 1141 steel, which required a heat treatment after rough machining and broaching operations. By converting to GM 88M ARMASTEEL, heat treatment was eliminated and the weight of the rough part was reduced.

By converting to GM 88M ARMASTEEL for this universal joint yoke, hole thru hub could be cast in . . . eliminating a drilling operation and reducing weight of part approximately 30%. GM 88M ARMASTEEL part has lower piece price than forging formerly used.

85

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 19

"BREAKTHROUGH"—"DYNAPAK"

SYNONYMS IN ADVANCED METAL WORKING

Metallurgists and tool engineers have achieved success in their search for a versatile, practical machine for extruding, forming, and forging tomorrow's high-strength metals and alloys.

A breakthrough was at hand when it was discovered that many of these metals exhibit hydrodynamic behavior when they are worked at very high velocities, with high rates of energy application.

For example, where an extrusion process normally is performed at velocities of 1 to 5 fps and at pressures to 175,000 psi, high energy extrusion takes place at velocities to 200 fps and at pressures of 250,000 psi and above.

While the phenomena of high energy forming characteristics of metals are not yet fully understood, it is known that metals so formed exhibit increased flow with little or no spring back.

But the real breakthrough could not occur until science had perfected machines that could generate these velocities and pressures in a safe and practical manner, to produce end-products of high physical and dimensional integrity.

SUCH A BREAKTHROUGH IS DYNAPAK.

DYNAPAK

DYNAPAK is a pneumatically energized machine that develops velocities to 500 fps and controls them to ± ½ fps... **DYNAPAK** is a versatile multi-purpose machine that can forge, extrude, or form, and can be readily converted from one process to another...**DYNAPAK** develops 40,000 foot-pounds of energy in a 6 inch machine that is less than 2 feet square and 10 feet long, weighs 3000 pounds and can literally be bench mounted. A 36 inch **DYNAPAK** generates 1,500,000 foot pounds of energy...**DYNAPAK** is attractively packaged—can be utilized in clean manufacturing areas...**DYNAPAK** produces parts that can not be produced in any other way, because the extremely high pressures literally force metal into every crevice of the die. **DYNAPAK** extrudes web thicknesses to one-hundredth of an inch—forges to zero draft angle—produces exceptionally good surface finishes...**DYNAPAK** is equally applicable with today's materials and production problems, and involves extremely low initial investment... **DYNAPAK** is more than a new machine, or a means of implementing a new concept. It is in itself a totally new concept—a new philosophy. **DYNAPAK** IS SAFE (no explosives are used), VERSATILE, PRACTICAL, OPERATIONAL.

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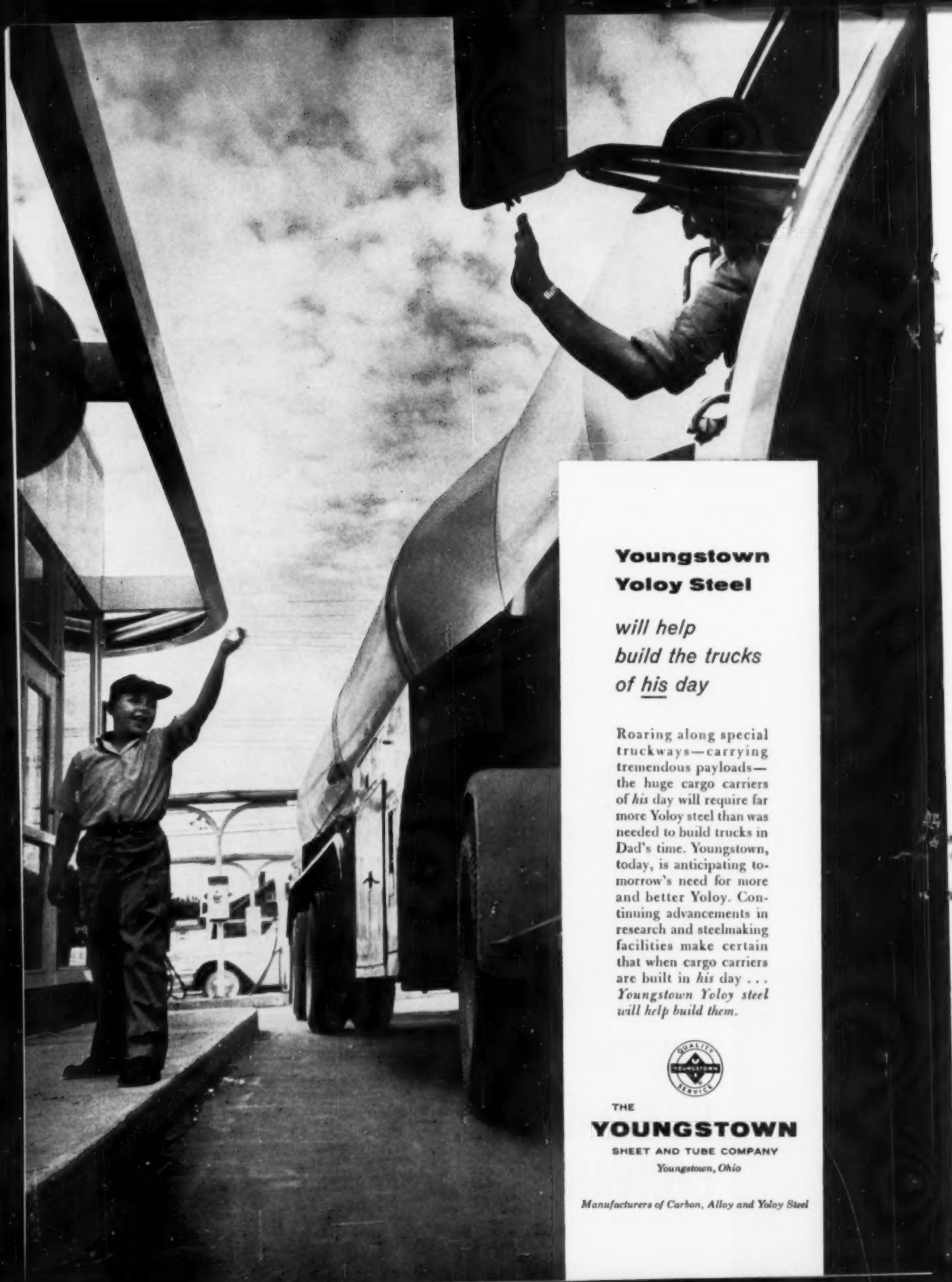

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of his day

Roaring along special truckways—carrying tremendous payloads—the huge cargo carriers of *his* day will require far more Yoloy steel than was needed to build trucks in Dad's time. Youngstown, today, is anticipating tomorrow's need for more and better Yoloy. Continuing advancements in research and steelmaking facilities make certain that when cargo carriers are built in *his* day . . . *Youngstown Yoloy steel will help build them.*

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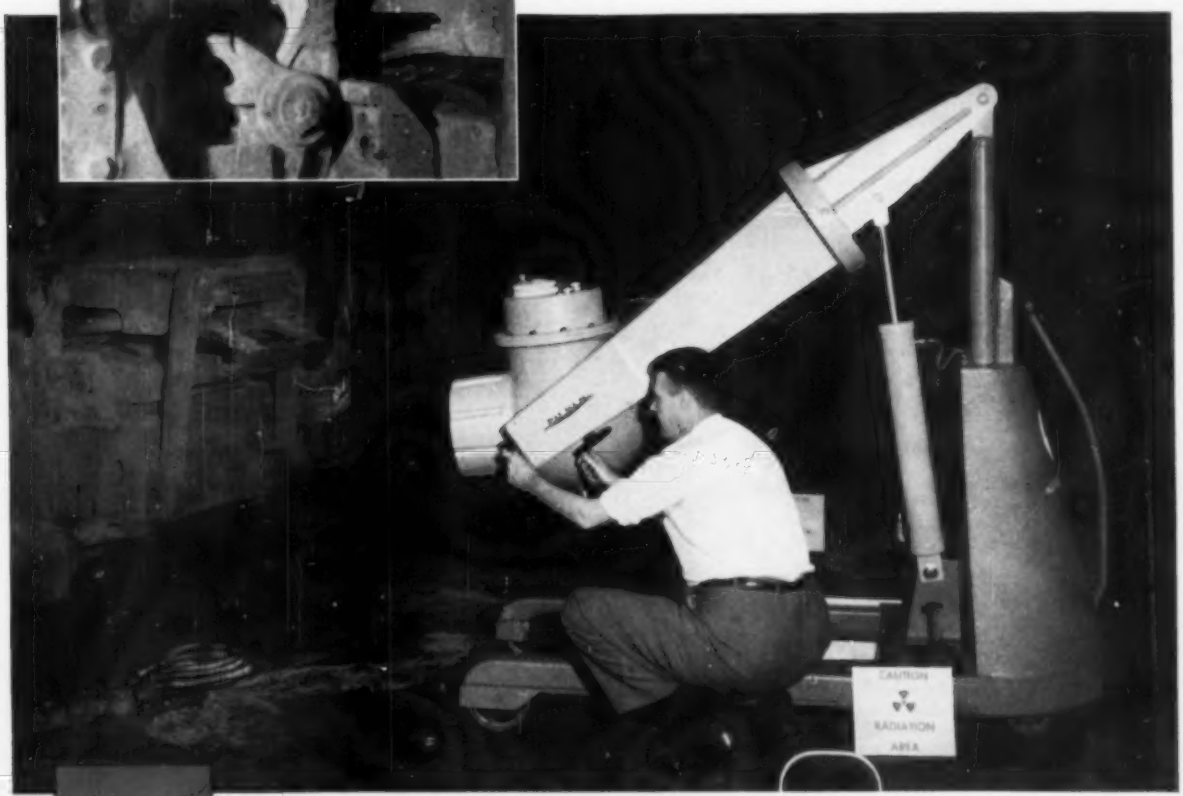

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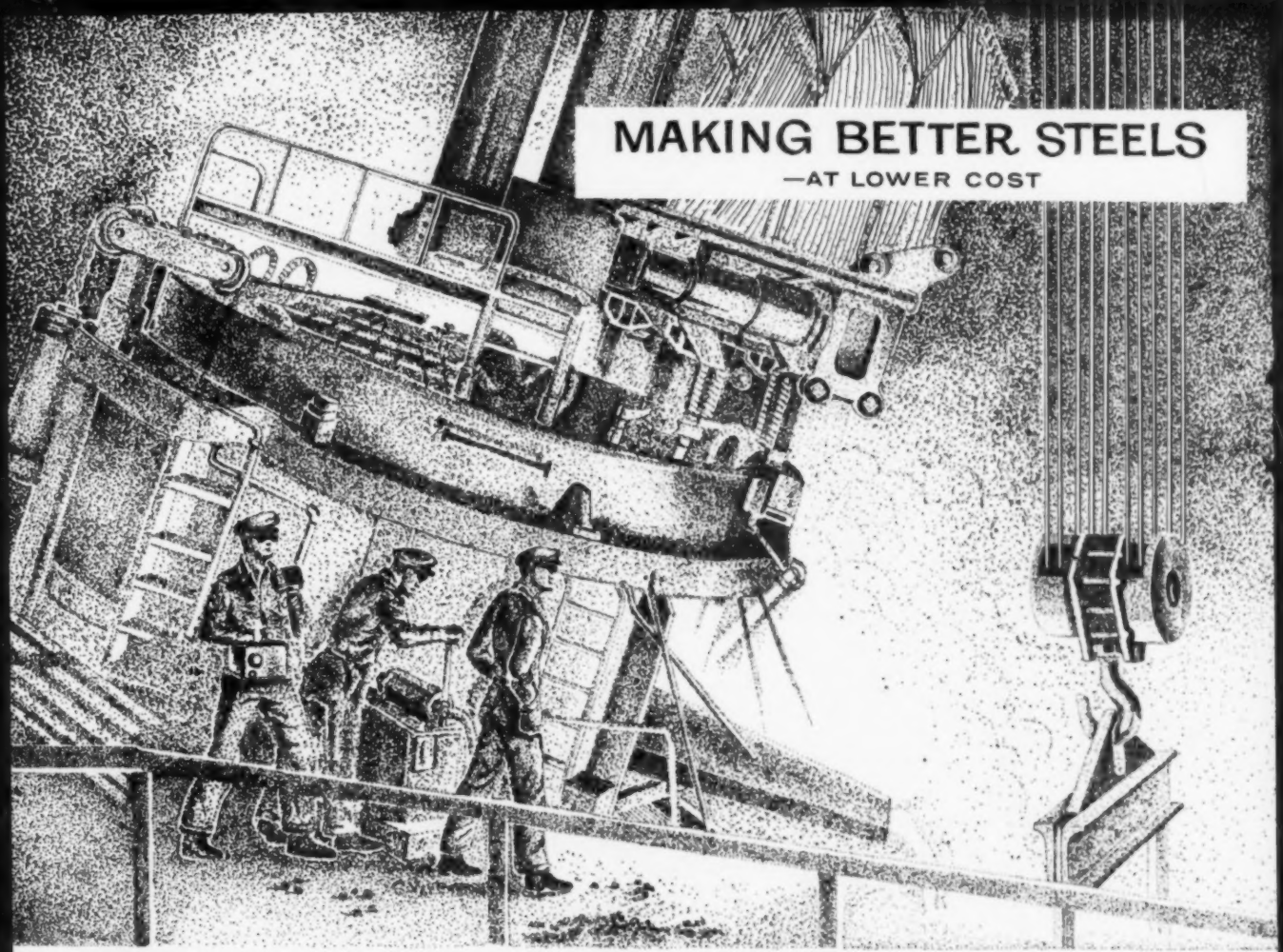

TAPPING

. . . a heat at just the right pouring temperature is typical of the melter's technical mastery. Another important factor in making better steels at lower cost is the revolutionary **Unitrode® nipple** which "welds" the joints of **GLC Graphite Electrode columns.**

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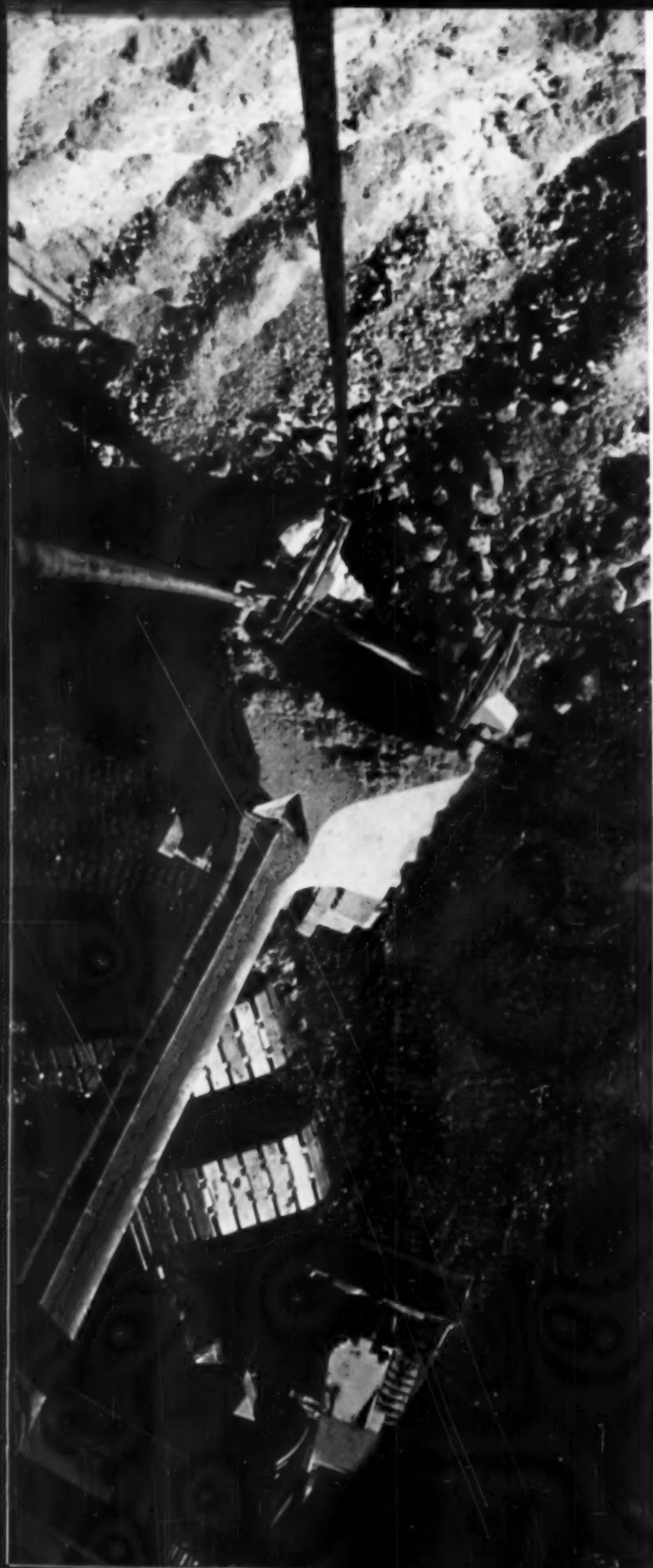

Big Paul digs and dumps 105 tons in 50 seconds!

USS "T-1" and TRI-TEN Steels cut dead weight—boost strength

Even from a 100-foot-high perch, the mammoth size of the bucket of Big Paul, the King of Spades, is hard to comprehend.

There are three of these 70-yard giants—all built by Marion Power Shovel Company. All achieve strength and toughness with least weight by the use of USS "T-1" Constructional Alloy Steel and USS TRI-TEN High-Strength Low-Alloy Steel.

Big Paul sets the pace at the Peabody Coal Company's River King mine near Freeburg, Illinois. It rams through rock and shale to uncover some two million tons of coal per year.

Since 1950, the art of big shovel making has increased dipper size from 35 to 45, 55, 60, and now 70 cubic yards per bite. Most of the buckets and dipper sticks of these giant shovels are made of USS "T-1" Steel, for otherwise, it would be almost impossible to make them light enough and tough enough. They hold up in this service, taking terrific impact abrasion and shock loading, even in the dead of winter. This is possible because USS "T-1" Steel retains its toughness at temperatures far below zero.

Dipper Size Increased 25%

USS "T-1" Steel has often enabled a boost in the capacity of original equipment without increasing weight. For example, a 20-yard bucket was replaced with a 24-yard "T-1" Steel job. Other dippers were boosted from 26 yards to 32, and 36 yards to 45—increases of 25%.

Many other parts—dipper stick, bail handles and crowd rack—are built stronger and lighter with this 90,000 psi minimum yield strength constructional alloy steel. (USS "T-1" Steel plates up to 2½ inches thick inclusive are *now* available with a minimum yield strength of 100,000 psi.)

The booms and A-frames of most shovels over 45 yards are designed with high-strength low-alloy steels with 50,000 minimum yield point . . . usually USS TRI-TEN Steel.

Perhaps you need a steel that offers higher yield strength, extraordinary toughness and resistance to impact abrasion, combined with relative ease of fabrication. USS "T-1" Steel is your answer, and we'll gladly help you adapt it to your application. For free booklet, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania

USS, "T-1" and TRI-TEN are registered trademarks

◀ 70-yard dipper and handle, crowd rack, bail and sheave blocks—all built stronger and lighter with USS "T-1" Steel.

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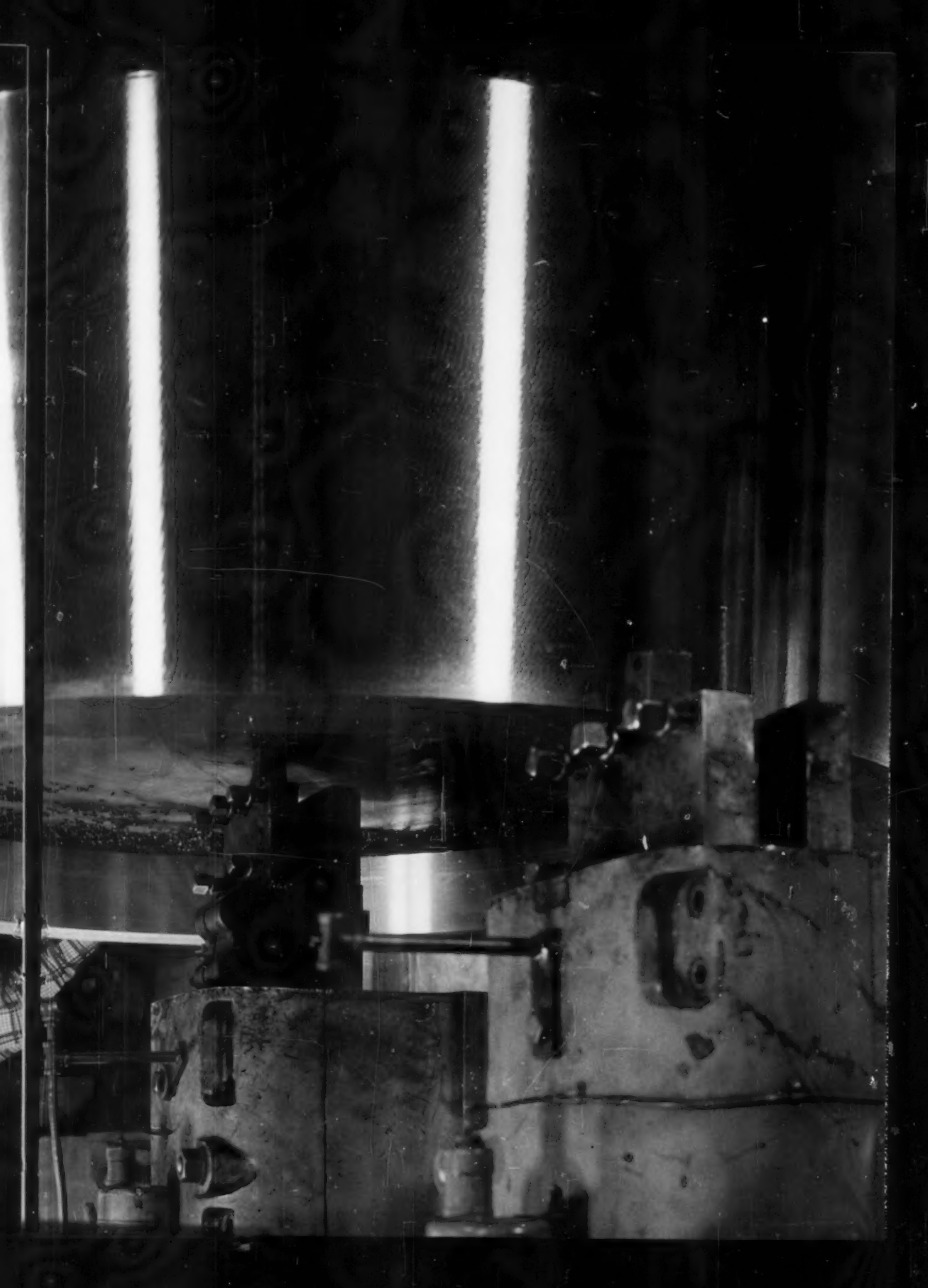

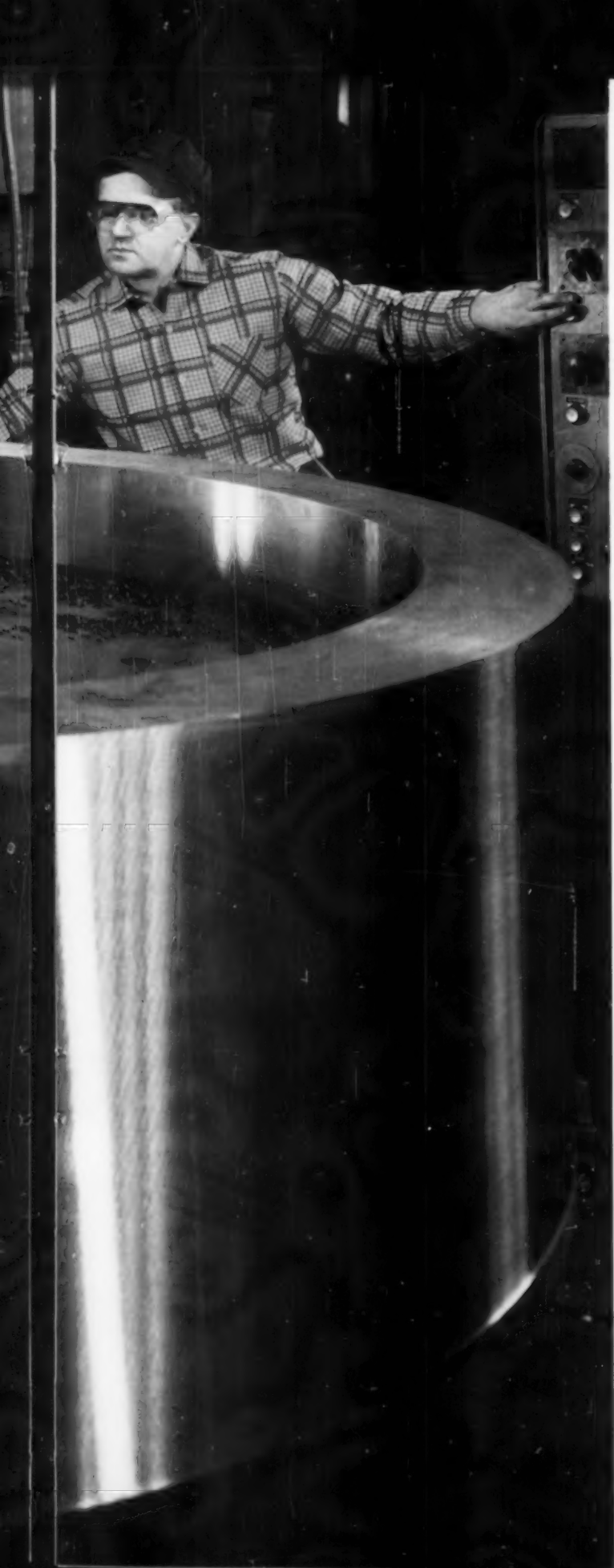

12 tons of forged steel for Yankee fission

The picture shows a steam generator tube sheet forging (one of four) destined for a 134,000-KW nuclear-fueled power plant owned by the Yankee Atomic Electric Company, in Rowe, Massachusetts.

It's a $50-million plant that uses a pressurized water reactor. The USS Quality Forging tube sheet is 85" in diameter by 26 7/16" thick. Some 1600 holes will be drilled through the forging longitudinally, and in these holes will be placed stainless steel tubes which will carry high pressure, high temperature main coolant water.

The forged tube sheet is made from carbon steel with a pinch (.057%) of vanadium in it. Starting from the raw ingot, it was heated, forged, rough machined, normalized, tempered, rough machined again, then quenched and tempered. It received a great variety of tests along the way—including several ultrasonic tests. The forging, as shipped, weighed 25,500 pounds.

Nuclear power plant designers have known from the beginning that it is extremely important to use highest quality components. That's the reason why they come so often to United States Steel for its justly famous USS Quality Forgings. And although the one shown here is not complicated, the Forgings Division of USS Homestead District Works has produced a great many complex forgings in everything from carbon to stainless steel, including discs, tapered domes, flanges and cylinders of all types.

No matter what kind of a forging you need, isn't it a good feeling to know that the men who will make it have a solid background of experience? We'd appreciate your inquiries or requests for our free folder on USS Nuclear Forgings. Just write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS

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United States Steel

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IN REFRACTORY CONCRETE DOME:

Circular Revolving Hearth Furnace featuring an unusual inner dome constructed with a castable refractory bonded with LUMNITE calcium-aluminate cement. Furnace diameter is 17 feet; 9" thick concrete dome has 289 holes (5" diameter). Heat passes downward through dome openings to anneal shells in furnace.

. . . for low cost furnace construction and maintenance

- Refractory concrete (with ATLAS* LUMNITE cement) stands up under continuous soaking heat . . . protects against thermal shock due to heating-cooling cycles . . . provides insulation.
- Easy, economical to place . . . by precasting, troweling or guniting . . . concrete reaches high strength 24 hours after placing.

For maximum convenience, use castables made with LUMNITE* cement. These are packaged mixtures, ready for use. Simply add water, mix and place. Made and distributed by leading manufacturers of refractories.

UNIVERSAL ATLAS CEMENTS

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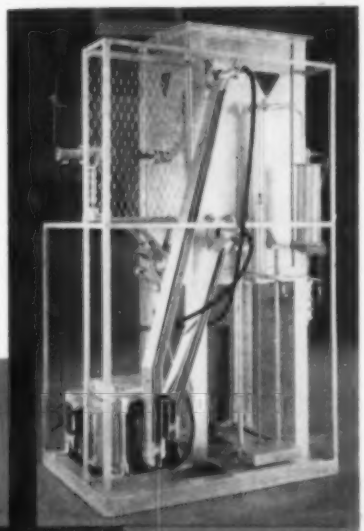

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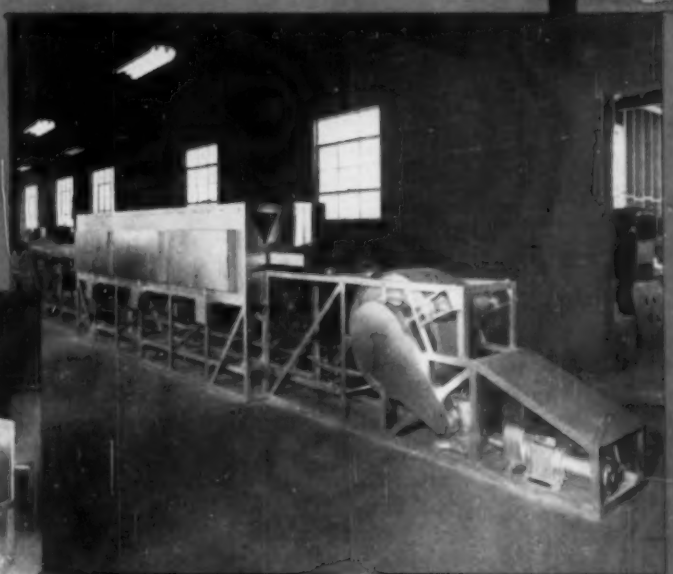
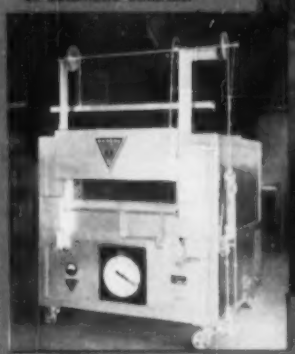
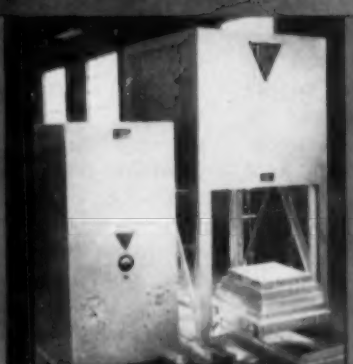


ABOVE
A vertical carbon-resistor tube furnace for fundamental research in metallurgy and related fields. Maintains plus or minus 20° F up to maximum of 5000° F. Maximum flexibility of heat-up rate with wide range turn-down. Also available in horizontal design.



LEFT
A tungsten reduction furnace. Continuous-belt alloy muffle. A typical example of Pereco sectionalized, straight-line production units. With or without protective atmosphere at ranges to 1950° F. —2100° F.

Units shown are typical examples of scope of the Pereco line. While many standard units, in a wide range of sizes or with modifications will handle the majority of special requirements, Pereco is prepared and qualified, through their long experience, to design and recommend the proper unit for the most specialized need.



LEFT
A high temperature, inverted pit or elevator type furnace with plug door. Door serves as hearth and, when lowered, rolls forward for easily loading heavy or bulky work. For temperatures to 2750° F. (2900° F. available).

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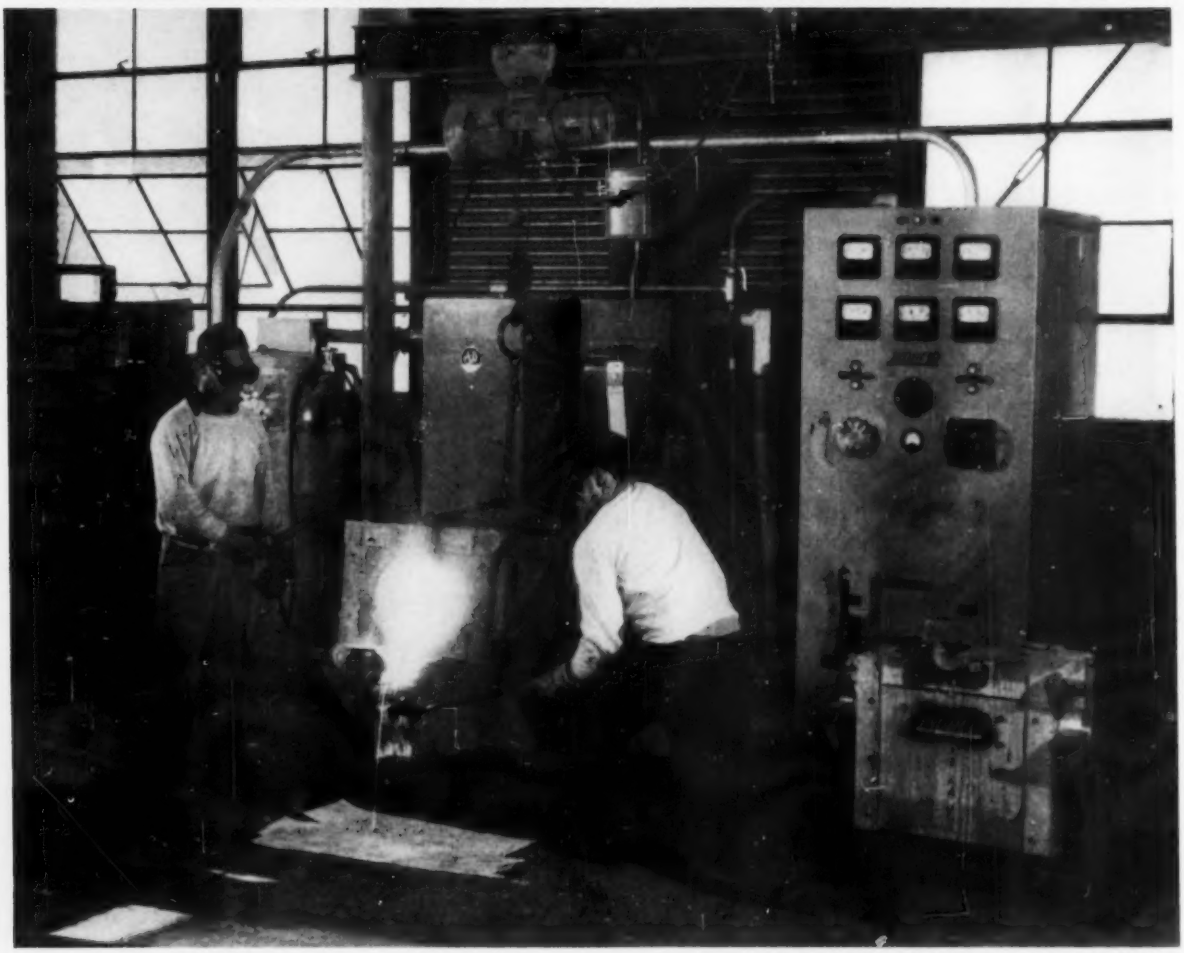

PHOTO COURTESY OF INVESTMENT CASTING COMPANY.

INVESTMENT CASTING Gets Extra Castings Per Day With INDUCTO Furnaces

The efficiency and performance of the INDUCTO high-frequency induction furnaces at Investment Casting Company, Springfield, New Jersey, account for extra castings per day. For in addition to high melting speeds and the resulting low metal losses, the INDUCTO equipment helps minimize rejects. The controllable analysis of alloys in heat after heat and the homogeneity of melts contribute to consistently higher quality castings.

Investment Casting Company benefits from other features of the INDUCTO melting equipment, too! The rugged welded construction of the furnace frame assures longer lining life through less distortion. The compact control panel puts all the controls, including the selector switches, within convenient reach of the operator while occupying very little floor space. The water-cooled power leads enter the furnace through the trunnion, thereby reducing twisting and flexing in addition to providing shorter leads for greater operating efficiency.

Why not learn how you, too, can save time and money through the use of modern INDUCTO metal melting equipment? Write today for Bulletin 70.

INDUCTOTHERM corporation

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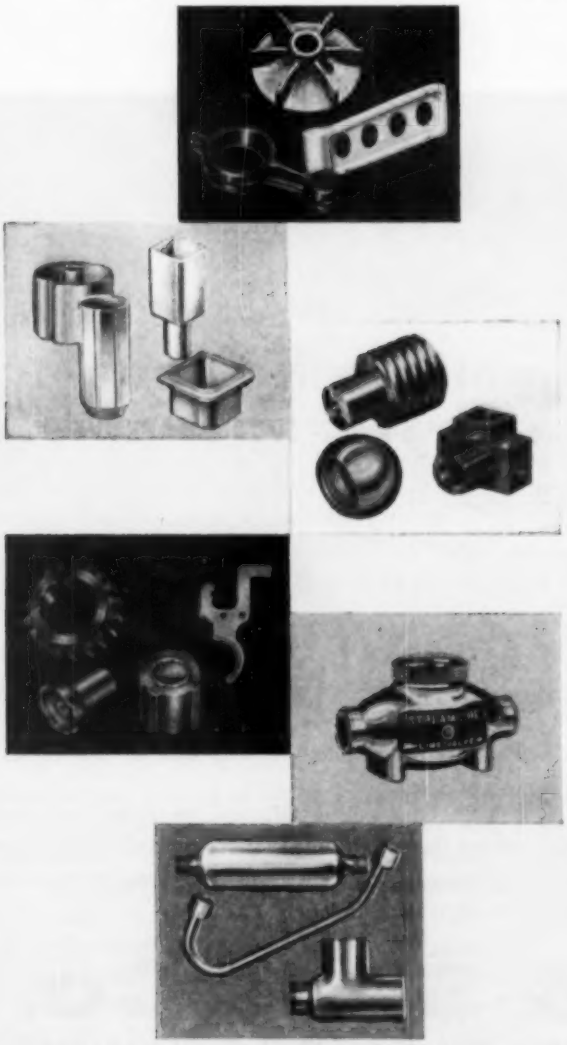
To obtain the desired physical and design requirements in a part at the lowest unit cost, there is usually one specific process by which that part can be most successfully and economically manufactured. Because the Mueller Brass Co. offers all these methods of production, you get sound engineering, the best method of fabrication and the assurance of getting the best product at the lowest cost. Sales and engineering service is available to you at Mueller Brass Co. offices throughout the United States. Make Mueller Brass Co. your one dependable source for all your fabricated part needs.



forgings

The Mueller Brass Co. is the world's largest producer of brass, bronze and aluminum forgings.

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The Mueller Brass Co. now offers "Cold-Prest" non-ferrous and ferrous impact extrusions. Flexible new facilities makes practical either long or short production runs of simple or complex shaped parts on an economical basis.

screw machine products

The Mueller Brass Co. maintains one of the largest automatic screw machine departments in the country, specializing in the manufacture of non-ferrous parts . . . completely equipped to perform secondary operations.

powder metal parts

Precision ferrous and non-ferrous powder metal parts are available from Mueller Brass Co. through its subsidiary, The American Sintael Corporation.

castings

The Mueller Brass Co. has a modern foundry equipped to produce quality brass and bronze castings to your specifications.

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The Mueller Brass Co. offers complete facilities for producing formed copper tube shapes and assemblies to the most demanding tolerances.

also producers of:

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260

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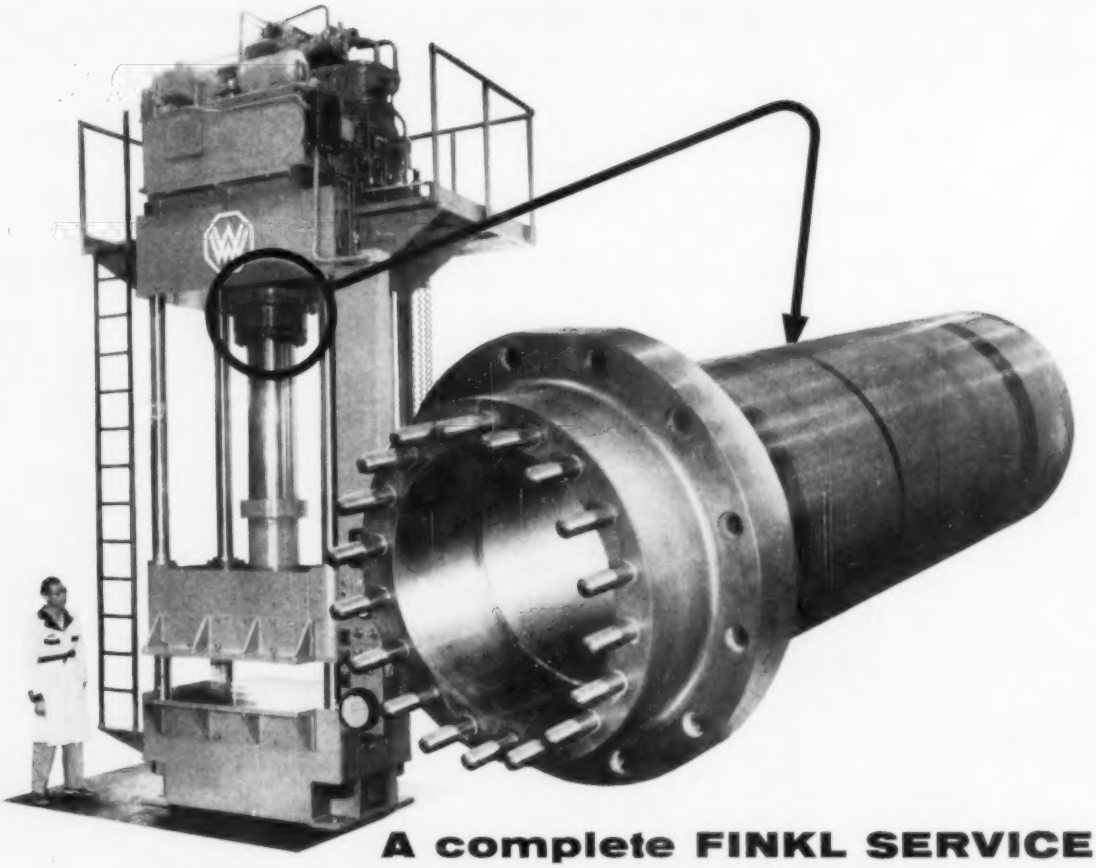

A complete FINKL SERVICE - FROM BLUEPRINT TO FINISHED PART

Many companies profit from Finkl's complete package service on finished machine parts. Williams-White & Company of Moline, Illinois, manufacturers of heavy machinery, called on Finkl for the forged steel, main cylinder shown above. It is used on a 300 ton plastic molding press employed for pilot molding procedures prior to production molding runs.

The entire cylinder was handled in our plant. Made of C-1035 steel from our electric furnace melt shop, the part was forged, heat treated, rough and finished machined under one roof. The 17″ bore was ground to $\begin{matrix}+.003''\\-.000''\end{matrix}$. Final dimensions, as delivered and installed, were 6′-1″ long with the main body 22″ in diameter.

With modern equipment and skilled craftsman, we do jobs both larger and smaller than the cylinder shown. The important thing is we do all of them well. Next time you are planning a machine part call a Finkl engineer and learn how you can profit by having it done under one roof.

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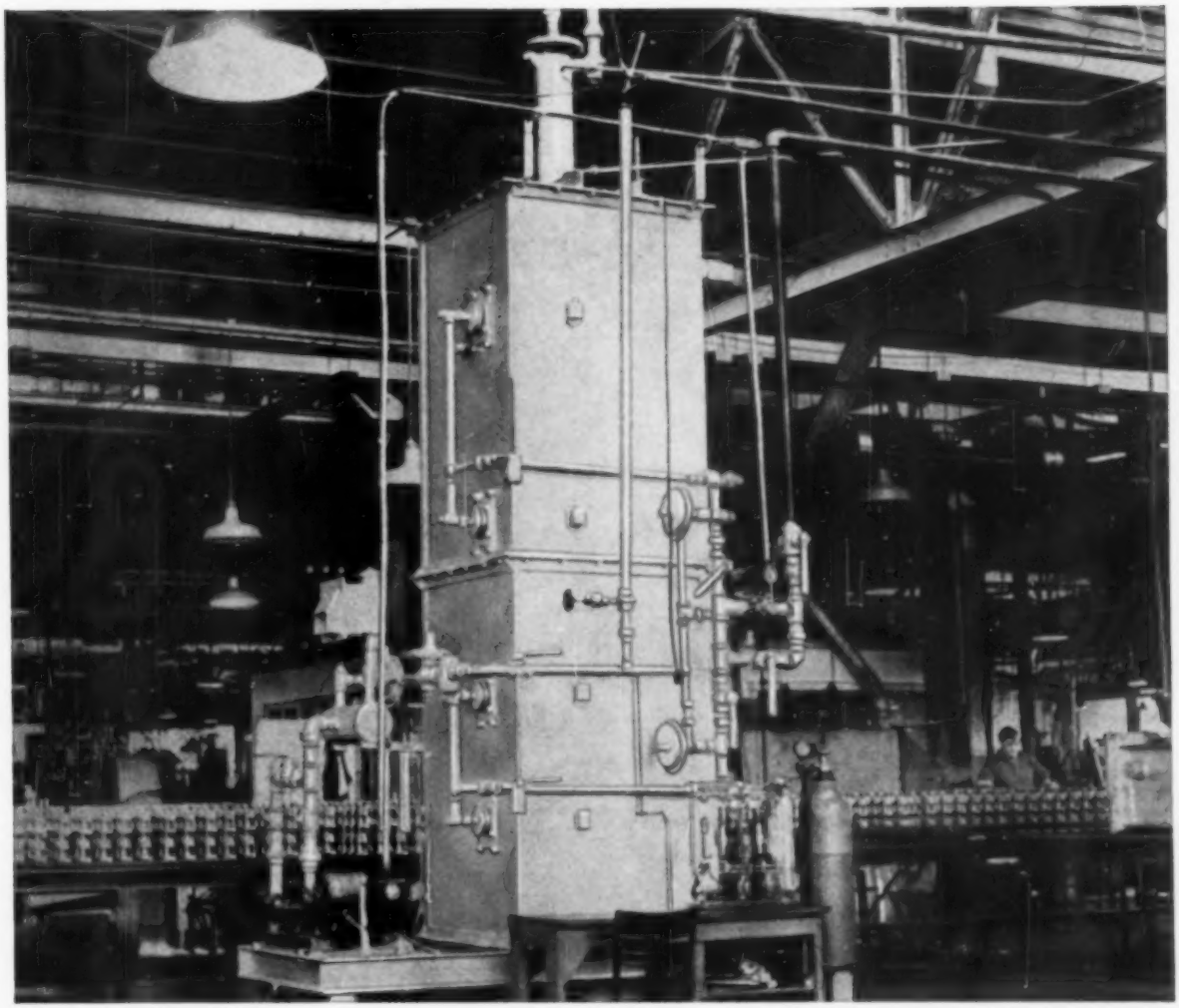
1,800,000 cfh of RX generator atmosphere



That's the combined capacity of all the Surface RX® gas generators sold since this first one started operating April 4, 1941. This was the first practical catalytic gas generator for continuous bright gas carburizing . . . and it's still in use at Warner Gear Division, Borg-Warner Corp.

Such long-term reliability is only one of the reasons why so many plants standardize on Surface gas generators. Controllability, flexibility, turn-down operation, variety of gases and capacities are some of the other reasons. We'll be happy to tell you more about them.

Surface Combustion Corporation, 2377 Dorr St., Toledo, 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

See new Autocarb® Systems at the Metal Show, Booth 321

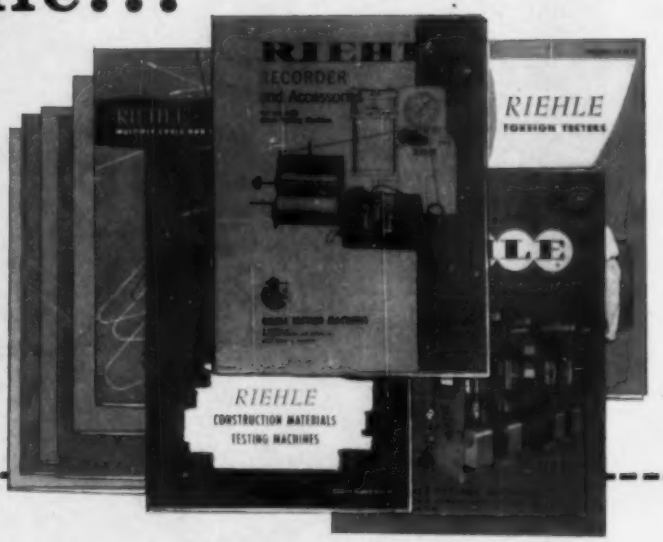
Surface

wherever heat is used in industry

now

complete your Riehle testing machine reference file...

You can take the first step toward solving your materials problems by bringing your Riehle testing machines catalog file up to date. Check the list below, clip it to your letterhead, and we'll send the catalogs you request promptly, without obligation.



- ☐ Universal Hydraulic Testing Machines and Accessories
- ☐ Universal Screw Power Testing Machines and Accessories
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- ☐ Creep and Stress-Rupture Testing Machines
- ☐ Losenhausen Fatigue Testing Machines
- ☐ Brinell Hardness Testers
- ☐ Vickers Hardness Testers
- ☐ Portable Hardness Testers
- ☐ Cable and Wire Testers
- ☐ Horizontal Tensile Testing Machines
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- ☐ Riehle Recorder and Accessories
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Riehle TESTING MACHINES

A DIVISION OF

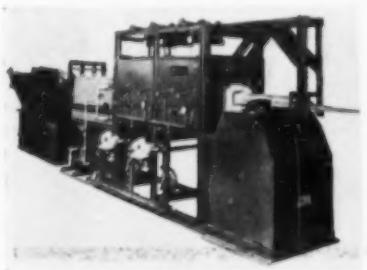
American Machine and Metals, Inc.

EAST MOLINE, ILLINOIS

APPLICATION and EQUIPMENT new products

Shaker Hearth Furnace

The American Gas Furnace Co. has announced a new line of reciprocating furnaces designed for the bright annealing and bright hardening of small stainless steel parts at temperatures up to 1900° F. The latest model has a capacity of approximately 100 lb. A forward movement is imparted to

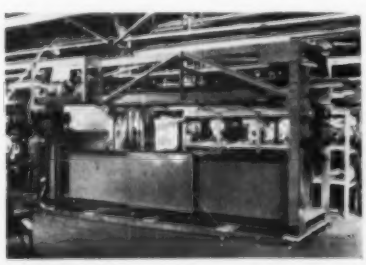


the work conveying muffle and the workpieces resting in it. The forward movement is interrupted suddenly, causing the workpieces to advance by their own momentum. An alloy muffle incorporates a purging, heating and water-jacketed cooling section, and seals into an automatic conveyorized oil tank.

For further information circle No. 651 on literature request card, page 48-B.

Conversion Coating

A new conversion coating machine has been announced by Hanson-Van Winkle-Munning Co. It is recommended for blackening, phosphating,



bright dipping, precleaning and pickling. Selective timers control each treatment tank. The machine loads and unloads automatically. The only moving components are the elevator framework, which runs the length of the machine, and the work load. Chains and drive provide travel from station to station and return to starting point. Another drive lowers and raises the elevator framework.

For further information circle No. 652 on literature request card, page 48-B.

Vacuum Etcher

Nuclear Materials & Equipment Corp. has announced a cathodic vacuum etcher for metallographic samples, complex alloys and dispersions which are difficult to etch or cannot be etched satisfactorily by chemical means. It is available in models suitable for either remote handling in hot areas or for direct use in unirradiated areas. Etching time is 1 to 3 min.

For further information circle No. 653 on literature request card, page 48-B.

Ultrasonic Machine Tool

A bench-type ultrasonic machine tool has been announced by the Sheffield Corp. It requires less than 2 by 4 ft. of bench space, but is capable of handling production as well as experimental machining of hard brittle materials. The machine has an effective machining area ranging from 1/64 to 1 in. in materials such as germanium, silicon, ferrite, hardened steel and carbide. Model No. 200-B2 utilizes a magnetostrictive transducer to provide up to 25,000 machining strokes per second. The transducer is powered by a 110-volt, 60-cycle, a.c. electronic generator supplying 250 watts output. An automatic tuning device in the generator senses and compensates for tool wear.

For further information circle No. 654 on literature request card, page 48-B.

Compacting Press

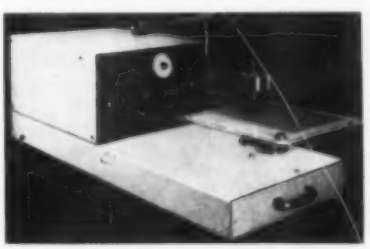
New single-pressure powdered metal and ceramic compacting presses have been announced by F. J. Stokes Corp. The new 20-ton presses can make tablets up to 3 in. in diameter and 2-in. depth of fill, at the rate of 16 to 48 pieces per minute, depending on the material being compacted. Press adjustments have been grouped together at the front of the machine. Indicators close to the compacting

point show the exact amount of upper punch entrance and the location of the fill stop.

For further information circle No. 655 on literature request card, page 48-B.

Film Tester

An instrument which can determine film properties in a manner that can be recorded in numerical values has been announced by the Forma Scientific Co. This machine rates cohesion, adhesion, mar and abrasion resistance,



impact resistance, scrub resistance and cross-hatch test for brittleness. These factors are rated numerically by specialized tools which are attached to the machine for each test. Run-of-the-mill laboratory panels, regardless of size or thickness, can be evaluated.

For further information circle No. 656 on literature request card, page 48-B.

Clad Metal

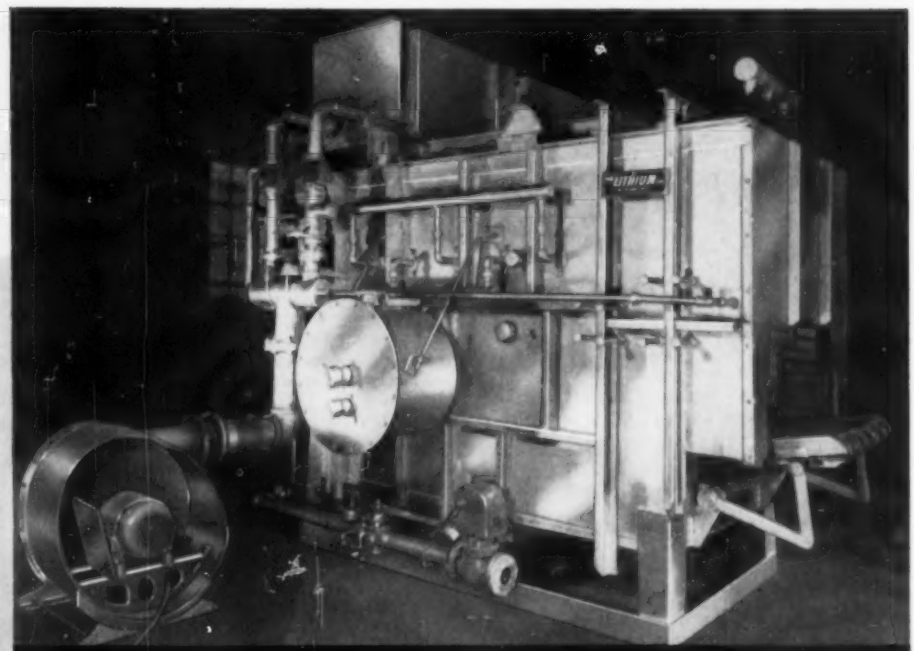
Metals & Controls Corp.'s General Plate Div. has announced aluminum-clad copper featuring a five-ply con-

SPENCER blowers

NOTE:
Furnace is used by The Lithium Co. to demonstrate quality heating processes. Upon request, furnace is placed in various plants to prove the processes.

FURNACE
HEARTH AREA...2' 6" x 6' 0"
DOOR HEIGHT.....10"
TEMP. RANGE...1200-2500°F
FUEL: Oil or Gas

BLOWER
TYPE: SPENCER CENTRIFUGAL TURBO-COMPRESSOR.



DIRECT FIRED RECUPERATIVE ATMOSPHERE SCALE-FREE HEATING FURNACE BY THE LITHIUM CO. . . . EQUIPPED WITH SPENCER BLOWER.

. . . preferred on countless industrial heating applications

SPENCER blowers . . . competitively priced . . . are consistently preferred by leading manufacturers of industrial furnaces of all types because of:

Complete Dependability—Rugged castings, sheet steel fabrication, simple construction and wide clearances mean long, trouble-free performance . . . assured proper air delivery.

Engineering Cooperation—The vast experience and thorough technical knowledge of field representatives and staff engineers are always available to assist in developing or adapting a reliable Spencer blower to any new or unusual need.

Whatever *your* blower requirements, for incorporation on original equipment or for replacement, it will pay to check with SPENCER.

Request Bulletin 126-B containing complete information and specifications on Spencer Blowers.

SPENCER HARTFORD

The **SPENCER TURBINE COMPANY**
HARTFORD 6, CONNECTICUT

OTHER QUALITY SPENCER PRODUCTS

STATIONARY VACUUM SYSTEMS

PORTABLE VACUUM CLEANERS

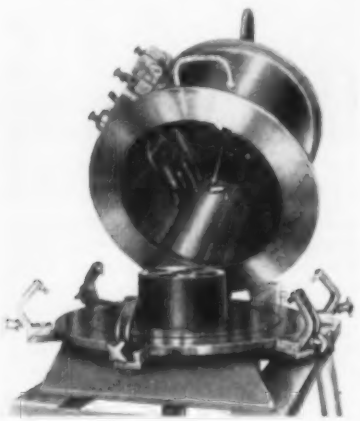
PNEUMATIC CONVEYING SYSTEMS

struction having a copper core up to 40% of the total strip thickness. This results in a composite metal stock with improved heat conductivity. All components of aluminum-iron-copper strip are joined by a metallurgical bond without the use of intermediate brazing materials.

For further information circle No. 657 on literature request card, page 48-B.

Vacuum Furnace

A new furnace with multiple button hearth producing high-purity evaluation melts has been announced by Zak Machine Works, Inc. The chamber is water cooled and is charged at table top level. Side and light ports are arranged around a vacuum sealed swivel that houses the water-cooled stinger rod. A glove

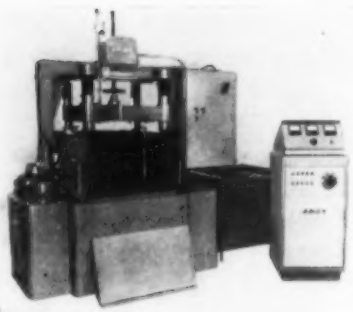


port is provided for inverting the buttons. This furnace makes small poundage melts with either consumable or nonconsumable electrodes by using interchangeable hearths. The vacuum system consists of a mechanical pump backing an oil diffusion pump. The power source is a 40-volt, 500-amp. rectifier, or power can be supplied by a d.c. welding source.

For further information circle No. 658 on literature request card, page 48-B.

Machining

The Research Div. of Elox Corp. has announced the development of a new machining process, electrochemical machining. Machining is completely electronic from start to finish. An electrode and workpiece are submerged in a saline solution and metal is removed by an electrochemical action controlled by a servo feed system that automatically advances the electrode into the workpiece as the machining progresses. The currents that can be used are unlimited and the gap between the electrode and workpiece which controls the accuracy of the finished product has a low limit of 0.015 in. at the present time. Metal



removal rates using a 5000 amp. power supply rating would be 30 cu. in. per hour with a minimum electrode area of 100 sq. in. Using a 50,000 amp. power supply rating, metal removal rates are 300 cu. in. per hour with a minimum electrode area of 1000 sq. in.

For further information circle No. 659 on literature request card, page 48-B.

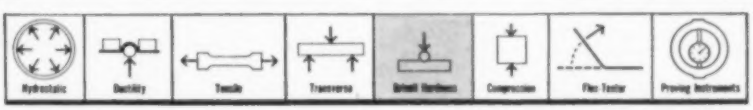
Brazing Wire

Little Falls Alloys has announced a new nickel-coated titanium wire for use primarily as a material for ceramic-to-metal brazing. The alloy will melt to bond with the ceramic, forming an air-tight seal. The wire is composed of approximately 71.5% titanium and 28.5% nickel, and is presently available in sizes from 0.062 to 0.004 in.

For further information circle No. 660 on literature request card, page 48-B.

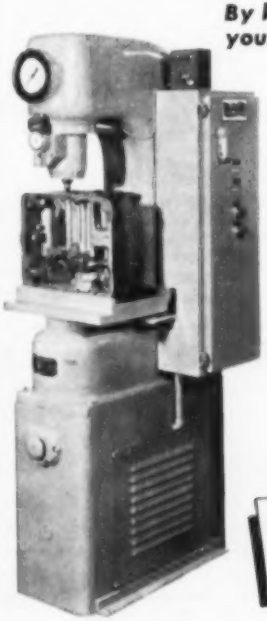
Low-Temperature Cabinets

Cincinnati Sub Zero Products will exhibit two new low temperature cabinets at the Metal Show, Oct. 27 to 31. Model AL-120-2 has a chamber size of 24 by 12 by 12 in. Standard operating range is —70 to —135° F., but this unit can be furnished with either higher or lower ranges of temperature. The refrigeration system is of the cascade type. Model SA-1803 (shown below) has an operating range



hardness tests increase plant capacity

By knowing the hardness of incoming parts you can reduce number of processing steps



Every production program has a bottleneck. Steel City Brinell testers can stop the broken-tool bottlenecks caused by too-hard parts.

For example, a maker of transmission cases has solved two problems with one "Color-Glance" tester. All incoming cases are tested; only hard ones need be annealed. Tool breakage is minimized, and limited annealing capacity is not overloaded.

Steel City "Color-Glance" Brinell hardness testers are high-production units. Relative hardness is shown by colored lights to reduce errors and fatigue. Optional equipment: workpiece locators, conveyor sections, counters, etc.

Steel City has solved many hardness-testing problems—laboratory, low-volume, portable. A standard machine may meet your needs.

Tell us your testing problem; ask for literature.

Enter Hardness Testing Contest BOOTH 442 METAL SHOW

Steel City Testing Machines Inc

8811 Lyndon Ave., Detroit 38, Mich.

ACHESON

dispersions digest

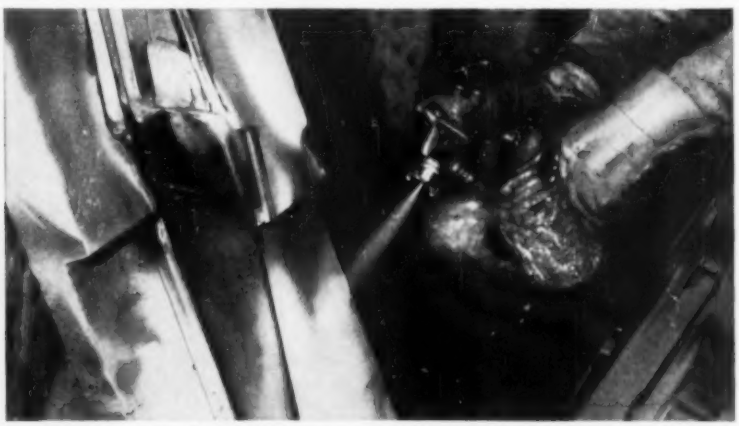
Reporting uses for

dag® BRAND DISPERSIONS

COLLOIDAL GRAPHITE, MOLY-SULFIDE, VERMICULITE, AND OTHER SOLIDS

SUPERIOR CASTINGS, LONGER DIE LIFE ATTRIBUTED TO 'DAG' DISPERSIONS

Die casters and molders are expressing a growing preference for Acheson 'dag' brand colloidal dispersions. The consistent high quality of these products and the multiple benefits they offer have obsoleted most other mold cavity coatings. As outlined below, Acheson dispersions greatly aid in the manufacture of more uniformly sound castings having smoother surface finishes, facilitate metal flow and parting, and consequently extend the effective service lives of the dies and molds on which they are used.



Acheson 'Prodag'®, spray-applied on permanent molds at Paragon Aluminum Corporation, has given them consistently higher quality castings and fewer rejects.

Better surface finish with 'Prodag' permanent mold coating is just one of the reasons why Paragon Aluminum Corporation, a Division of Detroit Harvester Company located at Monroe, Michigan, switched to this Acheson product. After four years of experimentation with other mold washes, Paragon chose 'Prodag' — Acheson semi-colloidal graphite in water — and has used it constantly the past seven years. The reasons for its choice are these; uniform consistency, excellent heat-transfer quality, and its hard, smooth, tenacious film which resists flaking and provides easier parting characteristics.

With about 95 per cent of its annual output of more than two million pounds of castings going to the automotive industry, Paragon must insist upon quality. 'Prodag' helps to maintain this standard. These parts for convertible automobile tops are precision-molded from both 355 and 319 aluminum alloy. Molds are preheated before each day's run to 600°F and the casting cycle maintains this temperature. The 'Prodag' dilution ratio is 1 to 4 parts water and is applied to the molds with a commercial spray gun. Aside from occasional touchup at points of greatest wear, this coating lasts through the entire run. Because of the physical contours involved in these comparatively small, light castings, they require rapid cooling in certain areas to insure uniform strength. The 'Prodag' coating — with its proven fast heat transfer ability — allows the castings to cool without breaks or pinholes. And by parting more easily, the high-finish castings which result have given Paragon Aluminum products wide acceptance in this demanding industry.

Typical parts cast at Paragon Aluminum include these automobile convertible top braces. More uniform strength, better finish, and fewer rejects result from this company's use of Acheson 'Prodag'.

Visit Acheson Booth No. 2777, National Metal Exposition

Colloidal graphite increases die life because of its stability at high temperatures, excellent lubricating qualities, and its ability to prevent adhesion and the scrubbing effect of hot metal. This cannot be said of conventional petroleum compounds which either decompose rapidly at temperatures above 300°F or do not possess the required lubricity necessary under good die casting procedures. It will not volatilize when in contact with the hot metal and cause pock marks due to gas formation. It will perform when present in extremely thin films which will not affect dimensions or cause discoloration of the parts being cast. And since it does not volatilize or otherwise be destroyed in the casting process, it does not need to be applied as often as other lubricants. This fact alone has often increased production as much as 25%. Investigate the use of an Acheson colloidal dispersion in solving your die casting problem . . . *It probably is the very answer you need.*

If you have a metal casting problem, call in your Acheson Service Engineer. Or if you prefer, write direct for additional information contained in our Bulletin No. 425. Address Dept. MP-108.

'dag' and 'Prodag' are trademarks registered in the U.S. Patent Office by Acheson Industries, Inc.

ACHESON *Colloids Company*

PORT HURON, MICHIGAN

A division of Acheson Industries, Inc.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

50TH ANNIVERSARY

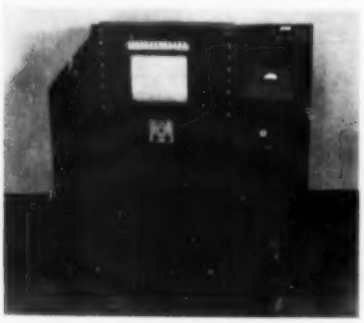
Offices in: Boston • Chicago • Cleveland • Dayton • Detroit • Los Angeles • Milwaukee New York • Philadelphia • Pittsburgh • Rochester • St. Louis • Toronto

to —180° F. The machine has a dual cascade refrigeration system and is portable.

For further information circle No. 661 on literature request card, page 48-B.

Resistance Heaters

A line of electric resistance heaters for close control of temperature in processing metals has been announced by Wheelco Instruments. They are produced by the Herscott Co. The units consist of a resistance heater, temperature sensing head and recording

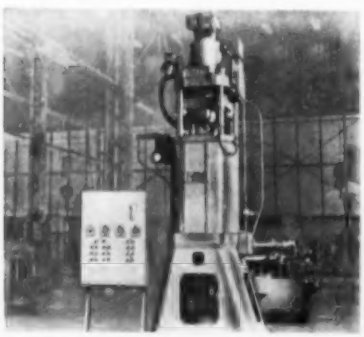


controller. Standard units are 10, 20, 30, 50 and 100 kw. Heaters are portable and can be used for wire drawing, extruding, hot heading, forging, upsetting, roll forming and heat treating. The Wheelco recorder-controller makes it possible to tie in heaters with an automatic work cycle.

For further information circle No. 662 on literature request card, page 48-B.

Powdered Metal Press

A powder compacting press, capable of compressing two entirely different materials in the same operation, has been announced by the Kux Machine

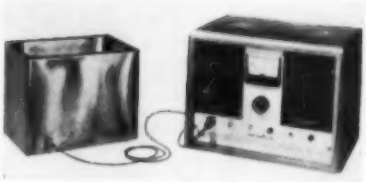


Co. Two independent, shuttle-type feed shoes and hoppers make possible bi-material compacting at production speeds up to 15 per minute. Presses are built in 50, 100, 200, 300 and 500-ton sizes.

For further information circle No. 663 on literature request card, page 48-B.

Ultrasonic Cleaner

A new ultrasonic cleaning unit with a 5-gal. tank has been announced by

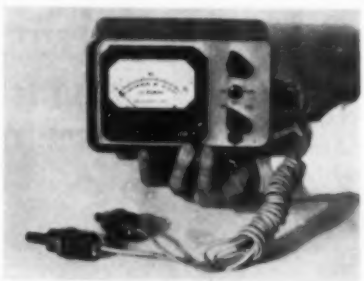


Acoustica Associates, Inc. A pulsing generator delivers an output of 1 kw. peak power which makes possible maximum cavitation with minimum power consumption. The tank is 14 by 10 by 9½ in. and is designed for cleaning large parts.

For further information circle No. 664 on literature request card, page 48-B.

High-Vacuum Gage

A new high-vacuum thermocouple gage and matching control, covering the range 2500 to 1 micron absolute, have been announced by NRC Equipment Corp. Response time of the new gage is from 1 to 1000 microns in less than 3 sec. Unit is unharmed by operation at pressures up to 60 psi. The two-station control supplies the power to and interprets the output



from the gages. It requires less than 6 watts of 115-volt, 60-cycle power and weighs less than 6 lb.

For further information circle No. 665 on literature request card, page 48-B.

Temperature Determination

Tempil® Corp. announces an extended line of temperature pellets to be exhibited at the National Metal Show, October 27 to 31. New pellets are available for 2550, 2600, 2650 and 2700° F. for high-temperature applications such as jet engines and rockets.

For further information circle No. 666 on literature request card, page 48-B.

Combination Rolling Mill

The development of a 2-high/4-high combination rolling mill for application in metallurgical production and research work has been announced by Loma Machine Mfg. Co. The new machine can be converted from a vertical strip mill to a horizontal mill used in the compacting of metal powders into sheet and strip. The heavy-duty design allows the mill to

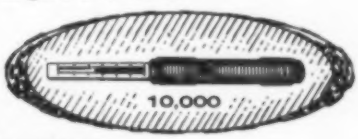
WORD FROM Waukee...

NEW LINE OF GAS-AIR MIXORS

As always, the actual user is the best salesman of a good product. Many of the furnace companies to whom we supply mixing equipment for generators report that their customers murmer quiet, but definitely audible noises of pleasure at the precision and simplicity of Waukee Mixors. When we started out, we hoped, of course, that this would be so — but we love being reassured.

For the benefit of those of you who have complained that we did not go large enough, we report that we now have Mixors in sizes to 15000 CFH for use with exothermic or endothermic generators, or other gas-mixing jobs. Best of all, the same Waukee features extend from the smallest 200 CFH unit to the 15000. This includes (1) the simple direct-ratio adjustment with no gears, (2) the easy-cleaning feature of a carburetor with a quickly removable top cap, so the user can keep the carburetor in top shape with 5 minutes of maintenance, (3) the bomb-sight type precision indicator dial which allows the carburetor to be accurately re-set — plus the fine clean design which has always been an important part of Waukee equipment.

As one furnace engineer exclaimed just the other day: "My gosh, it works as good as it looks!"



MILESTONE

By the time this ink gets dry, the 10,000th Waukee Flo-Meter will be off the line. We remember calling the entire organization together when we discovered we had made 1000 Flo-Meters. All four of us at the time were properly amazed. When last heard from, No. 1000 was still going strong. No 10,000 will have no such glorious career. We are just sentimental enough to take it fresh from the line, mount it on a varnished board like a tarpon, and hang it up in the front office.

Whoever gets No. 10,001 can be our guest for Milwaukee gemütlichkeit by identifying himself at 5138 North 35th Street, Milwaukee.

R.C.O.

Waukee FLO-METERS
GAS-AIR MIXORS
ROTARY-VANE COMPRESSORS
INDUSTRIAL WASHING MACHINES

The punishing impact of cleaning and peening operations calls for a metallic abrasive that can stand up and be counted.

The Blastrite line does that and more, simply because it's produced to consistently rigid specifications.

We have a small plant but we have large ideas about quality. You get guaranteed quality when you get Blastrite shot and grit.

Write for our catalog or outline your metallic abrasive requirements to our nearest representative.

Packaged the way you want it.

BUY BLASTRITE!

Steel • Pearlitic Malleable
"A" Iron • "B"
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ELECTRIC-ARC INC.

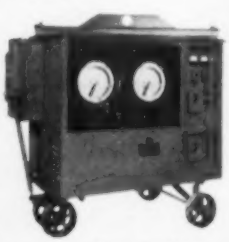
One of a Series on Applications of Electric Arc's Smith-Dolan Units — Today's Most Versatile Heat-Treating Tools.

STOP WELD FAILURE
with the
SMITH-DOLAN SYSTEM
of Low-Frequency Induction Heating

Here is the versatile heat-treating tool you need for producing sound welds easily and economically in carbo-alloy and other types of steel pipe . . . here is precision control of heating cycle when pre-heating and stress relieving — uniform, through-and-through heating of solid sections up to two feet thick and more — pushbutton operation — complete portability for on-the-job heat treating anywhere.

Many Money-Saving Applications — The Smith-Dolan System simplifies and upgrades work quality in numerous applications ranging from welding to forming and annealing. Units are available for 60 cycle heating in capacities ranging from 10 to 150 KVA . . . for 400 cycle heating . . . resistance heating. Pre-engineered with complete instrumentation, accessories.

"On Trial" Installations on Rental Basis — Prove the many Smith-Dolan advantages in your own plant without capital investment. Write, wire or phone.



Electronic recording gives permanent charts of heat run on this standard Smith-Dolan model. Coils permit work at 50 feet or more from unit. Eye hooks provide for easy handling by crane. Products ranging from a fraction of an inch to 10 feet in diameter can be heat treated on the job.

New Brochure — Send today for your copy of "Smith-Dolan System of Low-Frequency Induction Heating."

Electric Arc, inc.

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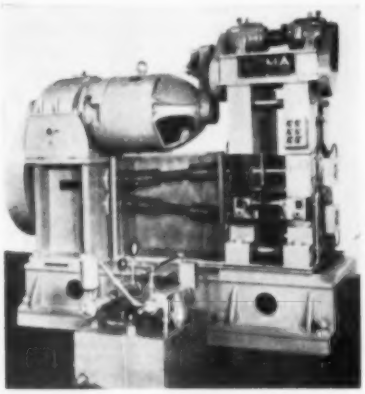
Bigelow 3-3211
Representatives in Principal Cities

take reductions of more than 50% per pass while maintaining tolerances as close as 5% of thickness. The 2-high arrangement is used for either hot or cold breakdown rolling of plate and sheet, and grooved rolls are also available to process rounds, squares and other shapes. In the 4-high setup strip is cold finish rolled to gages as



thin as 0.002 in. The optional conversion feature allows the mill to be arranged in the horizontal plane for the direct compacting of powder into sheet and strip. For such an operation a special feed hopper, powder entry guide and exit chute are applied to the 8½ in. diameter 2-high rolls so they can produce compacted materials up to ⅛ in. thick.

For further information circle No. 667 on literature request card, page 48-B.

Atmosphere Furnace

A new atmosphere box furnace for operation to 2000° F. has been announced by the Pilot Plant Div. of Lindberg Engineering Co. The chamber dimensions are 8 by 13 by 5 in.

All electrical components and controls are mounted in the furnace base and prewired and piped. Furnace chamber is protected by an automatic flame curtain which ignites when the furnace door begins to open.

For further information circle No. 668 on literature request card, page 48-B.

Wire Flattening Mill

At the National Metal Exposition, October 27 to 31, the Fenn Mfg. Co. will exhibit a tandem wire flattening mill line which will consist of a loose bundle pay-off reel, a two-high rolling mill with 8 in. diam. carbide shell rolls. A model 3TH turks head will be mounted directly behind the mill to edge the stock and the material then will be coiled in a traversing bundle on a hydraulic take-up reel. This entire line will be producing a section 0.020 by 0.103 in. at a speed of 500 fpm.

For further information circle No. 669 on literature request card, page 48-B.

Nondestructive Inspection

New, multi-frequency equipment for nondestructive inspection of both nonferrous and nonmagnetic metals has been announced by Magnetic Analysis Corp. This equipment is adapted for production line or independent testing of tubing, bars and wire for surface and subsurface defects, grade, dimensions, and physical and metallurgical properties. Inspection speeds range from 200 to 600 ft. per min. Coils are available for testing material from ⅛ to 3 in. outside diameters. Multi-frequency equipment utilizes two frequencies operating simultaneously, with two flaw detection circuits and one property variation detection circuit for each frequency. Three frequency ranges of seven frequencies each are available, covering from 1.8 to 700 kc.

For further information circle No. 670 on literature request card, page 48-B.

Forgings

The Metals Processing Div. of the Curtiss-Wright Corp. has announced a new forging technique which utilizes four die-faced hammers to forge a vertical, rotating billet of steel or other alloy into a final shape. The rotary forge will work hot or cold,

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Connector Panels T-E has one for your exact needs. These panels provide flexible, controlled control in transferring any number of thermocouples to indicating, multi-point recording and controlling pyrometers. Ideal for patch panel use, they are available in many compact shapes and sizes — with interchangeable plugs and jacks in I-C, C-C, and C-A. A panel for 48 thermocouples and 16 pyrometers measures only 13¼" x 7⅝". Polarity markings and screw-fastened connections make wiring easy.
Quick-Coupling Connectors These connectors permit fast, easy making and breaking of thermocouple circuits. Durable construction guarantees long, dependable usage. Polarized and mechanically interchangeable, all plugs and jacks are of standard matched thermocouple materials. Spring-loaded contacts with long wiping surfaces provide firm but easily broken connections.
Write for Bulletin 23 —H.
Thermo Electric Co. Inc.
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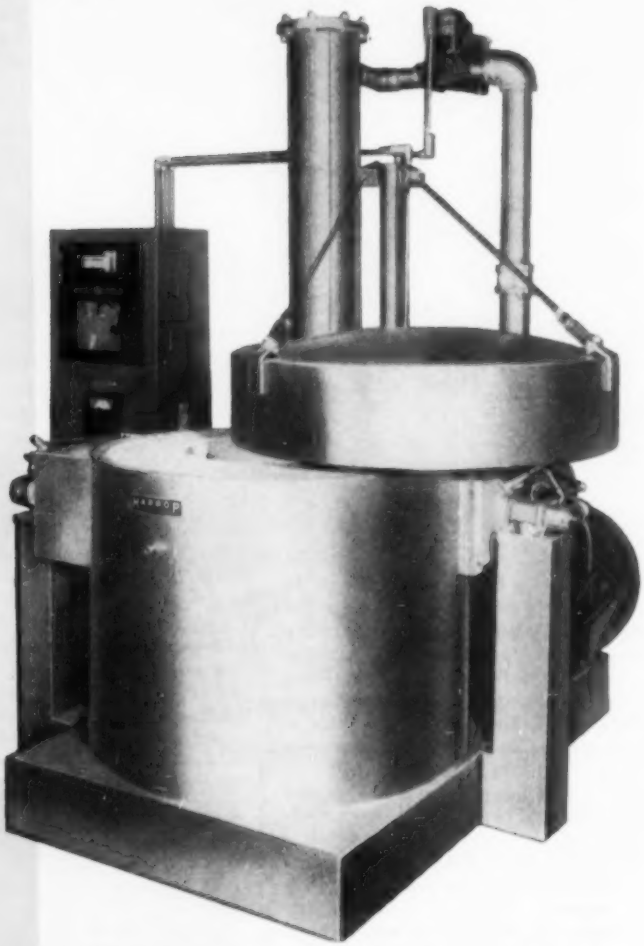
New Protection For YOUR Equipment— At Temperatures Up To 3300°F

ALUNDUM castables offer unusual advantages to all industries using high temperature installations*



Will fire continuously up to 3300°F. This Harrop gas-fired furnace, recently developed by the Electric Furnace Division of the Harrop Ceramic Service Company, Columbus, Ohio, is particularly applicable to the firing of ceramic oxide bodies. Norton ALUNDUM 33-I Insulating Castable selected for the inner lining of the furnace and its roof, provided completely satisfactory protection under repeated tests at highest operating temperatures.

The new Norton ALUNDUM Castables are made in two types: 33-I Insulating and 33-HD Heavy Duty. At temperatures up to 3300°F both types have been extremely successful in protecting high temperature processing — in many industries and many different installations.

ALUNDUM 33-I Insulating Castable is made up primarily of pure aluminum oxide bubbles, tiny and countless. Forming a network of air spaces, it assures excellent insulation, even at highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in many types of furnaces where high temperature conditions are particularly severe.

Both 33-I and 33-HD Castables are very easy to store, mix and use. With them you can cast simple or complex shapes quickly and economically, replace more expensive pre-fired shapes, and cut maintenance and replacement costs to very lowest. Ask your Norton Representative for details, and for the folder *Two Norton Castables*. Or write to NORTON COMPANY, Refractories Division, 329 New Bond Street, Worcester 6, Massachusetts.

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using round, square, solid or hollow billets. As-forged parts are as much as 36% lighter than conventional rough forgings. It is claimed that rotary forging gives greater strength because of the continuity of metal flow, which is unaffected by subsequent machining. A piece having seven outside diameters plus four inside diameters is forged in 40 sec. A rotary forged rocket nozzle requires 30 sec.

For further information circle No. 671 on literature request card, page 48-B.

Tool Heat Treating

Furnaces for heat treating small tools have been announced by the Waltz Furnace Co. These three-unit setups will heat treat every type of

high-speed steel including the cobalt type. Units are a preheat furnace, a drawing furnace, an atmosphere generator and two quench tanks, one for oil and one for water. A water-cooled chamber in back of the globar furnace to permit cooling of parts in controlled atmosphere is available as optional equipment. Furnaces are either 12 by 12 by 20 in. or 8 by 6 by 14 in.

For further information circle No. 672 on literature request card, page 48-B.

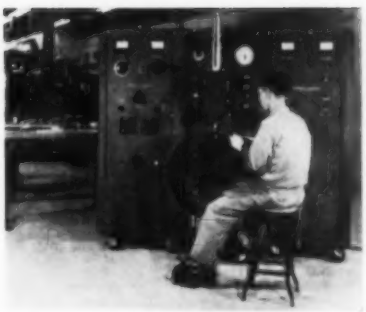
Phosphate Coating

A new phosphating material that provides a tight bond for paint, other organic finishes and metal drawing has been announced by Turco Products, Inc. The new material deposits a zinc phosphate coating on iron, steel, zinc and cadmium of up to 400 mg. per square foot. Turcoat 4333 meets USA-57-0-2C, Type II, Class C and MIL-S-5002 specifications. It may be applied by either spray washer or immersion.

For further information circle No. 673 on literature request card, page 48-B.

Ultrasonic Welder

Aeroprojects, Inc., has announced a 2000-watt ultrasonic welder which will join similar or dissimilar metals. A semiportable unit, it has a welding frame of box-beam construction and a hydraulic force system. Its transducer-coupling assembly consists of a nickel transducer, a coupling wedge



and a drive-reed which have been designed for this unit. The heavy-duty generator is contained in two separate cabinets. The welder is instrumented with an electronic cycle timer, and a Bourdon-tube force gage. Sonoweld is a spot-type welder and can be operated on a 230-volt circuit, and consumes a maximum of 3.5 kva. of power even when joining 0.050-in. 1100 aluminum sheet.

For further information circle No. 674 on literature request card, page 48-B.

Pyrometer

West Instrument Corp. has announced a portable hand pyrometer which requires no power source or special tools. It measures temperatures of convex, rotating or flat sur-

faces, for plastics, rubber, liquids, gases or molten soft metals. Accessories are available to suit most applications. The pyrometer is offered in 12 scale ranges.

For further information circle No. 675 on literature request card, page 48-B.

Illuminator

A new vertical illuminator for use with its line of Cycloptic stereoscopic microscopes has been announced by the American Optical Co. It provides vertical, shadowless illumination into deep, small-diameter orifices where the angle is too acute for standard oblique illumination. The illuminator consists of a lamphouse with a special bracket and hinge pin for attachment to a stand, a vertical reflector that

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A perfect diamond penetrator is essential to accurate hardness testing. Since one point of hardness on the "ROCKWELL" scale represents only 80 millionths of an inch penetration—only 40 millionths on a Superficial tester—the slightest imperfection will cause a false reading.

Only *perfect* Wilson Diamond Brale Penetrators are sold. Each diamond is flawless, with no chips or cracks. It's cut to an exact shape. Microscopic inspection of every diamond—one at a time—assures this perfection—and assures you of accurate hardness testing every time.

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The TUKON Tester measures extremely shallow indentations. It's used, for instance, by manufacturers of watches, hairsprings, needles, and fine wire. Laboratories use the TUKON for tests on individual crystals or particles of microscopic size. Producers of coatings, film, ceramics, and many other materials have made good use of the TUKON.

Three models are available to meet your individual requirements. TUKON Testers use both the Knoop and 136° Diamond Pyramid Indenter. Each TUKON Tester is a self-contained hardness testing instrument— no accessory equipment is needed. Knife edges and levers of fixed length are used throughout for application of exact load and freedom from internal friction.

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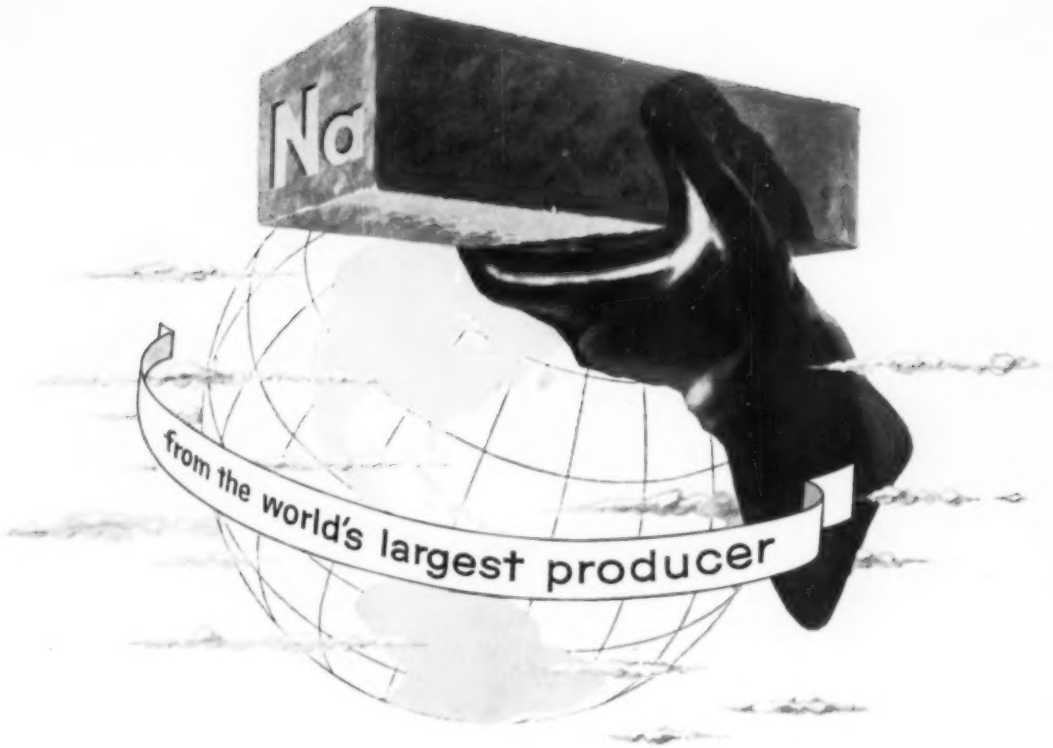

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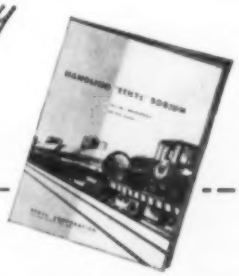

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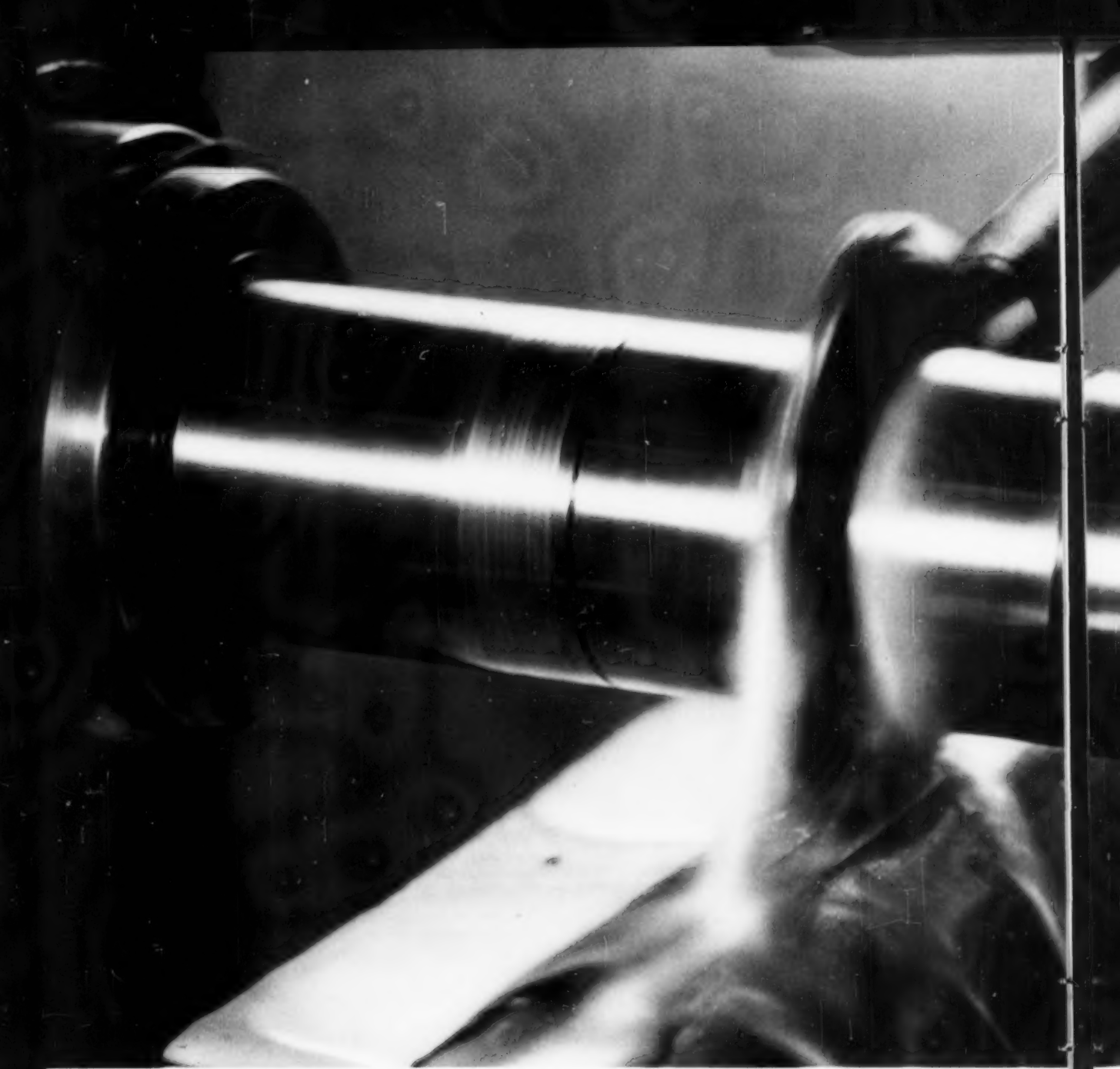

Cutting oil life jumped from 3 weeks to 3 months . . . tool life

GULF MAKES THINGS

At its Milford, Conn. plant, U.S. Electrical Motors turns out a complete line of motors ranging from ¼ to 250 hp, all precision built. For much of their close-tolerance machining they utilize emulsifying oils. Says Theodore O'Connor, Plant Superintendent:

"Until recently, we were using a soluble oil mixed in a 20-to-1 water-oil ratio to cut keyways in a variety of motor shafts. Then we switched to Gulfcut Heavy Duty Soluble Oil mixed 35-to-1. Service life of the cutting oil on this job jumped from 3 weeks to 3 months!

"The new mixture provides much better cooling. It has doubled our tool life. And we now hold closer tolerances—to plus or minus .001 on this operation."

HAVE YOU TRIED GULFCUT HEAVY DUTY SOLUBLE OIL?

Long and economical service life is only part of the story. This versatile oil has performed efficiently even when mixed in a 150-to-1 ratio! Its lubricating-cooling-pro-

U.S. ELECTRICAL MOTORS Inc. doubled tool life on this milling machine with Gulfcut Heavy Duty Soluble Oil. Keyway cut in the steel shaft is 4⅛" long; ⅜" wide; ⅜" deep. Speed 6.8 inches per minute milled. Tolerances held to ±.001. Pictured here are Theodore O'Connor, Plant Superintendent, and Peter Eaton, Gulf Sales Engineer.

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RUN BETTER!

tective properties meet a great variety of heavy duty machining needs, even in turning chrome-nickel steels and other tough alloys. It makes possible higher speeds, deeper cuts, finer finishes. It offers greater protection against corrosion and unusual resistance to rancidity. It will prove to you that Gulf makes things run better!

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SP-9362

Special Reports On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

mounts over the microscope objective and a variable transformer.

For further information circle No. 676 on literature request card, page 48-B.

Die Heater

A new die heater for aluminum extrusion dies has been announced by the Carl Mayer Corp. It is refractory lined, the work chamber is 24 by 24

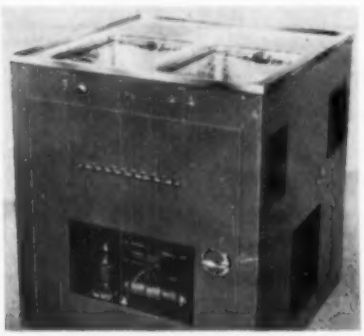
by 18 in. and temperature range is from 400 to 1000° F. This unit is supplied with either gas, electric or oil-fired burners.

For further information circle No. 677 on literature request card, page 48-B.

Rhodium Plating

New technically pure rhodium sulphate, a concentrate for rhodium electroplating, has been announced by Technic, Inc. Lower stress, high purity and finer grain are cited as advantages of the new concentrate.

For further information circle No. 678 on literature request card, page 48-B.



Ultrasonic Cleaning

The Blackstone Corp. has announced new ultrasonic cleaning equipment for parts and assemblies. It has two 10 by 14 by 10 in. stainless steel tanks for ultrasonic cleaning and ultrasonic rinsing. The solution in each tank is continuously circulated and filtered. Each tank is activated by multi-element magnetostrictive transducers operating at about 20 kc. per sec.

For further information circle No. 679 on literature request card, page 48-B.

Molybdenum Sheet FROM STOCK

Since the introduction of Fansteel's stocking program in January 1957, over 1000 customers have saved time and money by:

- √ accelerating engineering development programs
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IMMEDIATE DELIVERY ON THESE 7 SIZES OF DUCTILE MOLY "D" SHEET

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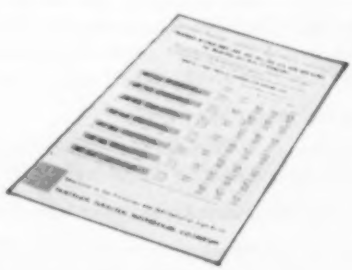

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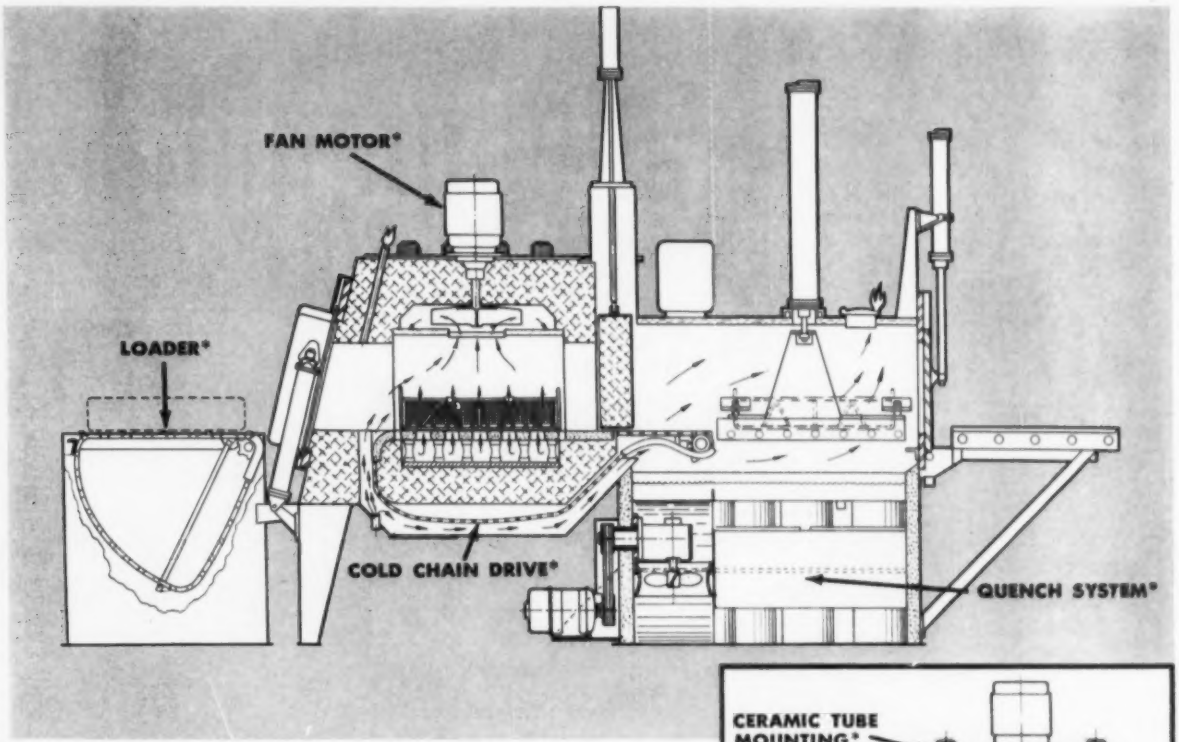

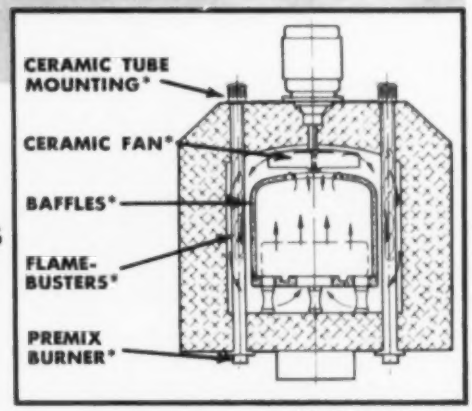

*Existing or Pending Patents

Ipsen announces new model "C" furnaces

for carburizing up to 2000°F

For years, the top operating temperature of conventional carburizing furnaces has been in the area of 1750°F, but the new Ipsen Model "C" Carburizing Furnace coasts at that temperature. The model "C" is engineered to meet modern requirements for high temperature carburizing.

EXCLUSIVE IPSEN FEATURES!

Here are some of the reasons why Ipsen Model "C" furnaces permit day-in and day-out operation at 2000°F:

1. Guaranteed super-alloyed ceramic heating tubes!
2. Unique tube mounting, sealed in compression!
3. Ceramic "Flame-Busters" increase heating efficiency 40%!
4. High hot-strength hearth and baffles for 100% forced convection heating!
5. Revolutionary, high-speed, forced circulation fan of alloyed ceramic construction!
6. Water-shielded fan shaft and motor!
7. New, fully enclosed, 100% premix ceramic burners!
8. "Cold chain" hot-work transfer mechanism with automatically welded precision chain!
9. Bevel gear driven quench oil propeller. . 5,000 gallons per minute!
10. Space saving automatic loaders and in-line transfer mechanisms!

Optional "*Dewtronik*" is the only automatic dew point control for either carburizing or ammoniated carbo-nitriding atmospheres.

Call your nearest Ipsen office for the complete facts on the NEW Ipsen Model "C" 2000°F Carburizing Furnace.

AUTOMATIC Ipsen HEAT TREATING UNITS

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YOU PLATE METAL
YOU PAINT METAL
YOU FINISH ALUMINUM
YOU STRIP ORGANIC FINISHES

NORTHWEST'S CHEMICALS DO IT BETTER!

Remember — YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER

Northwest's years of research in formulating and perfecting analytically correct, job-adjusted cleaners are your assurance of the right chemical for your job.

Northwest's Metal Cleaning Specialists have at their command such outstanding processes as LO HI pH — for cleaning prior to plating, painting or vitreous enameling; ALKALUME — for preparing aluminum for finishing and spot welding; INTERLOX — for phosphate coating; SPRA-LUBE — to control overspray of "todays" paints in water-wash paint booths; PAINT STRIPPERS — specific to your needs; SUPER-DRAW AND FLUID FILM — for drawing metals.

Northwest's production-tested chemicals and "Right the First Time" recommendations will save you money. Your Northwest Cleaning Specialist is as close as your phone.

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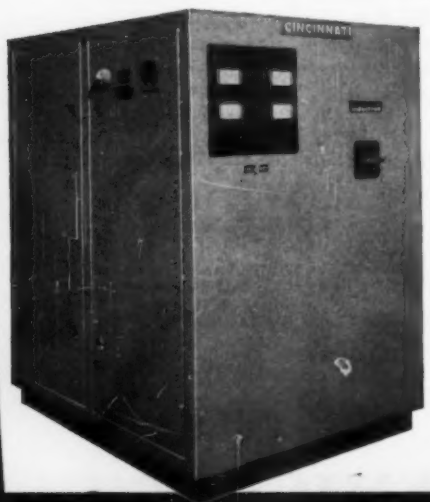

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APPLICATION and EQUIPMENT new literature

681. Abrasives
New catalog on various types of shot and grit abrasives. SAE specifications and types of cleaning and peening methods. *Cleveland Metal Abrasive*

682. Air Engineering
New 6-page Bulletin 135 on air engineering for the process and chemical industries. Heat removal, heat and moisture control. *Niagara Blower Co.*

683. Alloy Castings
New 8-page bulletin on ferrous alloy castings for the control of wear due to impact and abrasion. Application, production, physical properties. *American Manganese Steel Div.*

684. Alloy Castings
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

685. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications *Cannon-Muskegon*

686. Alloy Steel
14-page bulletin on two chromium-nickel alloy steels. Properties, working instructions, heat treatment, recommended uses. *Carpenter Steel*

687. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U.S. Steel*

688. Alloy Steels
Article on use of chromium-molybdenum-vanadium steel for service at elevated temperatures. Chemical composition, mechanical properties. Vancoram Review, V. 13, No. 1. *Vanadium Corp.*

689. Aluminum
24-page data book on high-strength aluminum - zinc - magnesium - chromium - titanium alloy. Properties, aging, corrosion. *Frontier Bronze*

690. Aluminum
16-page bulletin lists sizes, weights, lengths of alumium in rod bar, plate, sheet. Guide to selection, finishes, mechanical properties. *Ryerson*

691. Aluminum Cleaner
Data sheet on acid solvent cleaner for aluminum and its alloys. *Northwest Chemical*

692. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

693. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions*

694. Aluminum Extrusions
Catalog of stock extrusion dies. *Jarl Extrusions*

695. Aluminum Finish
Bulletin on new invisible finish for aluminum describes Alodine No. 1000 and includes flow sheet for immersion process. *Amchem Products, Inc.*

696. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

697. Ammonia
New 6 and 4-page bulletins on ammonia storage units and nitrogen generator. *Hamler Industries, Inc.*

698. Ammonia Dissociators
Data on Drever ammonia dissociators. Also nitriding, tempering, carburizing, and salt bath units. *W. H. Kay Co.*

699. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". *International Nickel*

700. Atmosphere Furnace
New Bulletin 865 on controlled atmosphere, continuous rotary retort furnace describes operation and construction. *American Gas Furnace*

701. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

702. Atmosphere Generators
New 4-page bulletin I-457 includes flow charts and cost analyses of inert gas system. *Gas Atmospheres*

703. Blast Cleaning
Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasive*

704. Blast Cleaning
16-page Bulletin 226 on blast cleaning equipment. Describes automatic continuous operation. *Pangborn*

705. Brazing
8-page reprint on dip brazing aluminum assemblies. Design of parts, equipment used. Maintenance, tooling. *Ajax Electric*

706. Brazing
16-page reprint on furnace brazing gives advantages of method, design factors and methods of handling assemblies and furnaces for brazing. *Electric Furnace*

707. Brazing
52-page publication GEA-3193C on how and where to use electric furnace brazing. Limiting creep of brazing metal, selecting the brazing metal, strength of furnace-brazed parts, how to braze cast iron, causes of distortion. *General Electric*

708. Brazing
New 24-page Bulletin 20 on low-temperature silver alloy brazing. *Handy & Harman*

709. Burners
Bulletin 214 on dual-fuel burner for ovens, kilns, driers, forge furnaces, heat treating and malleabilizing furnaces. *North American Mfg.*

710. Calibrating System
New ABC booklet on force measuring system. *Morehouse Machine*

711. Carbonitriding
28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

712. Castings
Literature on shell or sand castings of ArmaSteel, malleable iron or gray iron. *Central Foundry Div.*

713. Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

680. Extruded Shapes

Several hundred basic designs of copper-alloy extrusions, thick and thin, simple and complex, are shown on pages 14 and 15 of this 40-page booklet. Tabular data on properties of extrudable copper-base alloys, cross-sectional dimension tolerances and selection of the correct alloy are included. An 8-page section on machinability gives ratings of 21 alloys; rake angles for lathe turning; milling, threading, tapping and sawing data. The booklet concludes with some tips on designing and ordering extrusions. *Revere Copper & Brass, Inc.*

714. Centrifugal Castings
8-page brochure gives properties of most common grades of thermalloy centrifugally cast tube. Weight tables. *Electro-Alloys Div.*

715. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

716. Chromium Plating
4-page bulletin on new "crack-free" chromium plating process. *Metal & Thermit*

717. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning", discusses tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

718. Coated Metals
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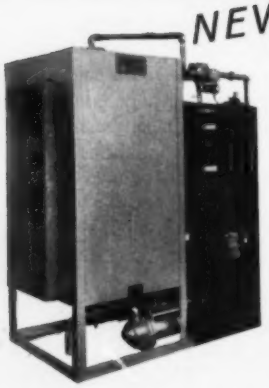

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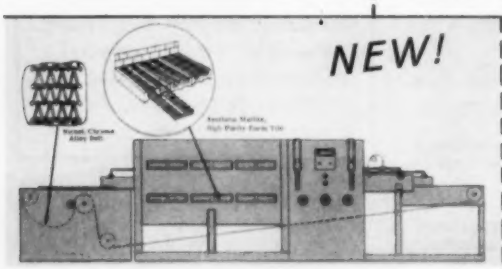

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12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

722. Corrosion of Copper
32-page reference booklet to aid in selecting copper alloy best suited for particular corrosive condition. 187 applications. *American Brass Co.*

723. Corrosion-Proof Equipment
Bulletins on corrosion-proof tanks, ventilating equipment, agitators, baskets. *Heil Process Equipment*

724. Corrosion Resistant Alloys
Data Sheet comparing corrosion resistance of zirconium, titanium, tantalum, Hastelloy "C" and stainless 316. *Damascus Tube Co.*

725. Creep Testers
Pocket-size creep load calculator that determines the pounds of weight needed on weight pan when testing specimens in creep testers. *Arcweld Mfg. Co.*

726. Creep Testing
New Bulletin RR-13-56 on testing machines for creep and stress-rupture tests. Tables. *Riehle*

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Data sheet on stress rupture and creep testing machine. Operation, calibration, maintenance, specifications. *Tinius Olsen*

728. Crucibles
Bulletin C1-55 on crucibles for service to 2900° F. *McDanel Refractory Porcelain*

729. Cutting Oil
New folder describing nine types of cutting oils for varied applications. *Gulf Oil*

730. Cutting Torch
4-page folder on process and torch for cutting, gouging, beveling and grooving all metals. *Arcair Co.*

731. Cutting Torch
Memco News June-July 1958, gives data on cutting, gouging, beveling, grooving torch. Various models, uses, power sources, case histories. *Miller Electric Mfg.*

732. Deep Drawing
Brochure on hydroforming discusses parts that can be made and costs of tooling for different shaped parts. *Hydroforming Co. of America*

733. Degreaser
Folder on automated degreaser. Cleaning and solvent cycles described. Features of equipment. *Detrex*

734. Degreasers
Folder on vapor and solvent degreasers describes equipment and advantages. *Randall Mfg.*

735. Degreasing
New Bulletin No. 70 on degreasing with trichlorethylene. Advantages and disadvantages. *Hooker Electrochemical*

736. Dehydrators
Bulletin SC-1013 on dehydrators for carbon dioxide, carbon monoxide, hydrocarbons, nitrogen, oxygen, natural gas, hydrogen and others. Operation and construction. *Selas*

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8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

738. Die Steel
Data sheet on Huron high-carbon, high-chromium die steel. Applications, forging, annealing, hardening, tempering. Properties. *Allegheny Ludlum*

739. Ductility Testing
Bulletin on simple method of determining ductility of materials before drawing. *Steel City Testing Machines*

740. Electric Furnaces
Bulletin No. 528 on electric furnace for investment casting. Weight of charge, melt time, power consumption for stainless, Stellite, gray iron, copper, brass. *Detroit Electric Furnace Div.*

741. Electric Furnaces
Data sheet describes and gives specifications of standard nonmetallic resistor furnaces. *Harrop Electric Furnace Div.*

742. Electric Furnaces
Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

743. Electric Furnaces
Folder on electric furnaces with zone control, temperature indication, automatic control. *L & L Mfg. Co.*

744. Electric Furnaces
8-page Bulletin 570 on heat treating, melting, metallurgical tube, research and sintering furnaces. Custom designs for special requirements. *Pereny*

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4-page folder describes controlled elec-

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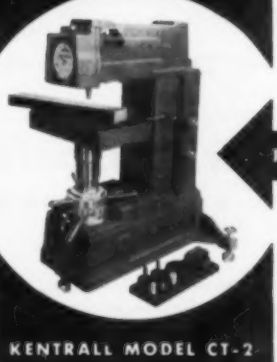

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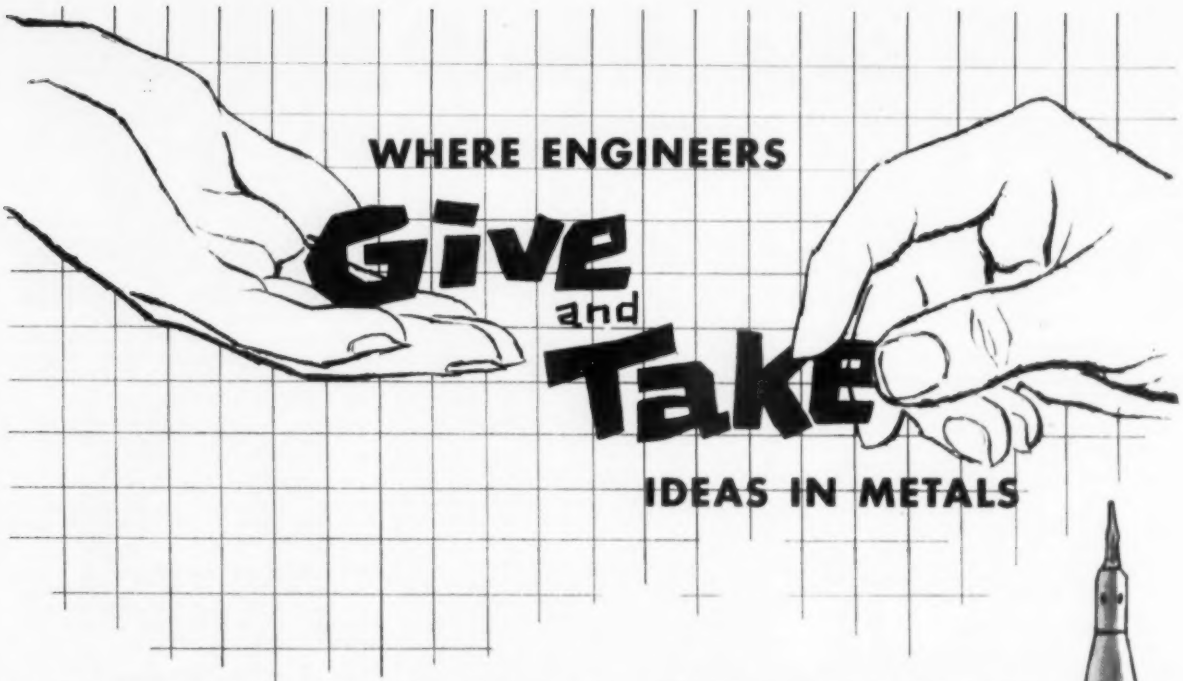

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tric heating unit. Features, advantages, uses. *Herscott Co., Inc.*

747. Electrochemicals
New 16-page booklet gives physical properties of 23 electrochemicals including silicon carbide, zirconium oxide and borides. *Norton Co.*

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8-page bulletin on new wire materials—Nickelply and Brassply, electrocoated steel wire. How it may be formed, bent and twisted without breaking the coating. *National Standard*

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20-page brochure describes ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

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8-page bulletin on extensometers for sheet metal and wire, compressometers, deflectometers and other accessories. *Baldwin-Lima-Hamilton*

751. Extrusions
New booklet describes advantages of Cold-Prest impact extrusions, design considerations and methods of production. Alloys used. *Mueller Brass Co.*

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Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

753. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

754. Finishing
Bulletin on Luster-On 52 conversion coating for zinc. *Chemical Corp.*

755. Flame Hardening
New Publication No. M-2015 on precision flame hardening machine with automatic operation. Specifications, design. *Cincinnati Milling Machine Co.*

756. Flow Meters
New 22-page Bulletin F-1607 on flow meters. Uses and characteristics. Tables of flow calculations. *Bristol Co.*

757. Flow Meters
Bulletin 203 on flow meters for gas used in heat treating. *Waukee Eng'g.*

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12-page booklet on how forged weldless rings and flanges are made. Case histories. *Standard Steel Works Div., B-L-H*

759. Forgings
Folder on facilities for production of flat-die forged products. Electronic equipment used. *Smith-Armstrong*

760. Formed Plate
Bulletin on stainless steel flanged heads. 246 available dies listed. *G. O. Carlson*

761. Freezer
Data on chest for use down to —95° F. for production and testing. *Revco*

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763. Furnace Elements
24-page Bulletin H on electric heating elements. Tabular data on physical and electrical specifications for various sizes. *Globar Div., Carborundum*

764. Furnace Fixtures
Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. *Fahralloy*

765. Furnaces
New bulletin on metallurgical test furnaces for tensile, creep and stress-rupture tests. Control panels. *Marshall Products*

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New Bulletin 463 on high temperature pusher furnaces. Operation and applications. Temperature to 2400° F. *C. I. Hayes*

767. Furnaces
New Bulletin 355 on convection furnaces with maximum operating temperature of 1350° F. Construction, applications, specification tables. *Hevi-Duty Electric*

768. Furnaces
Data on recirculating furnace. Temperature range 300 to 1650° F. *J. A. Kozma*

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New 12-page catalog on electric heat treating furnaces. Data on each of 57 models. Controls, instruments, elements and accessories. *Lucifer Furnaces, Inc.*

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Lists of surplus furnaces for sale. *Joe Martin Co.*

771. Furnaces
4-page reprint on high thermal head furnaces for continuous slab heating installation at Atlas Steels, Inc. Cross section view of radiamatic unit. *R-S Furnace*

772. Furnaces
32-page catalog of industrial equipment includes furnaces and furnace accessories, special valves, mechanical equipment, materials handling equipment. *Salem-Brosius*

773. Furnaces
Bulletin on controlled atmosphere furnaces and generating assemblies for annealing, brazing, hardening, sintering, soldering. *Sargeant & Wilbur, Inc.*

774. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

775. Gas Analysis
New 12-page Bulletin 837 on research instrument for analysis by gas and vapor chromatography. Advantages. *Burrell*

776. Gas Analyzer
New 8-page Bulletin No. 1703-4 on gas analyzer. Principle of operation. Special features. *Mine Safety Appliances*

777. Gold Plating
8-page paper gives bath composition, equipment and operating conditions, and metallurgical characteristics of 24K gold plate on various base metals. *Sel-Rex*

778. Graphite Electrodes
New 6-page folder describing graphite electrodes for electric furnaces. Stock list of threaded graphite electrodes and their corresponding nipples. *Great Lakes Carbon*

779. Hardness Conversions
Desk-size chart of conversions for Rockwell tests and other hardness scales. *Torsion Balance Co.*

780. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

781. Hardness Tester
Catalog 505 on Frank hardness tester for Rockwell B and C, Brinell and Vickers hardness tests. *Opto-Metric Tools*

782. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

783. Hardness Testers
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage Industries*

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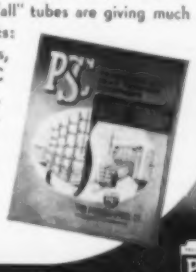
If you are using cast alloy tubes, we can quote you substantially less on our all-sheet alloy tubes. And, with dies on hand for many commonly used sizes of return bends, we can frequently save our customers this important cost. Records of scores of installations show PSC "Thin Wall" tubes are giving much longer service life. For instance, Michigan Malleable Iron Co. reports: "We show an average life of over 3½ years for your fabricated tubes, which is about double our experience with cast alloy tubes". In PSC tubes the return bends are of the same metal and thickness as the legs, promoting uniform flow of gas and minimizing carbon build-up and consequent burn-out. Precision-assembled in any design or dimension. Also sheet-alloy heat-treating retorts and covers, boxes, baskets, fixtures, tubes, etc. We invite your inquiries.



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THE PRESSED STEEL CO. · Wilkes-Barre, Pa.

A Review of the Phosphate Coatings

Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering, and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (ACP Granodine®). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (ACP Thermoil-Granodine®). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Iron phosphate (ACP Duridine®). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (ACP Lithoform®). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (ACP Alodine®). This is a relatively new protective coating for aluminum and aluminum alloys. It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (ACP Permadine®). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.

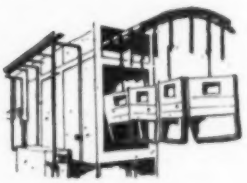
The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (ACP Granodraw®). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

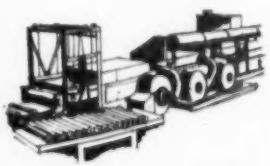
It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an ACP sales representative or write us at Ambler, Pa.

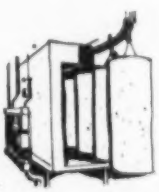
Typical Installations of Phosphate Coating Systems



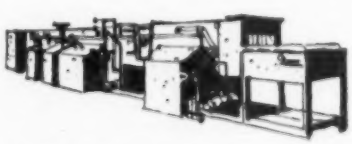
Customer: Truck manufacturer
Problem: Preparing cab parts for painting
Cycle: Phosphate wash; phosphate wash; rinse; chromic acid rinse; dry



Customer: Aluminum screen manufacturer
Problem: Final finish of aluminum shade screen
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry



Customer: Water heater manufacturer
Problem: Preparation of water heater shells for synthetic enameling
Cycle: Phosphate wash; rinse; chromic acid rinse; dry



Customer: Hardware manufacturer
Problem: Preparing hardware parts for painting
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry

Amchem Products, Inc.
Ambler 16, Pa.

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784. Hardness Testers
New 24-page Catalog No. DH-327 on accessory and special testing. *Wilson Mechanical Instrument Div.*

785. Hardness Testing
Bulletin A-18 on Alpha Co. Brinell hardness testing machines *Gries Industries*

786. Heat Treat Pots
Catalog on pressed steel pots for lead, salt, cyanide, oil tempering and metal melting. *Eclipse Industrial Combustion*

787. Heat Treating
Data sheets on Aeroheat 300 and Aeroheat 1000 heat treating salts. Properties, uses, operating characteristics. *American Cyanamid*

788. Heat Treating
New 8-page bulletin on heat treating. Data sheets on processes and processing equipment. Also covers annealing, brazing and hardening. *Ferrotherm*

789. Heat Treating
Monthly bulletin on used heat treating and plating equipment available for immediate delivery. *Metal Treating Equipment Exchange*

790. Heat Treating
4-page bulletin on protective coatings on steel from heat treating method. Prevention of carburization or decarburization, selective carburization. *Park Chemical Co.*

791. Heat Treating
Bulletin SC-176 on mechanized heat treating for any size of operation. Various mechanical handling devices used. *Surface Combustion*

792. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

793. Heat Treating Fixtures
4-page folder on retorts, baskets, trays, carburizing boxes, fans for heat treating. *Alloy Steel Fabrication Div., Aluminum & Architectural Metals Co.*

794. Heat Treating Fixtures
New 1959 catalog on complete line of baskets and fixtures. *Bix Co.*

795. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. *Pressed Steel*

796. Heat Treating Fixtures
32-page Catalog G-10A lists process equipment, heavy welded fabrications, muffles, trays, fixtures for furnaces, heat treating equipment, pickling equipment. *Rolock*

797. Heat Treating Fixtures
New 16-page Catalog M-7 on heat treating and corrosion resistant alloy fabrications. *Wiretex Mfg. Co.*

798. Heat Treating Furnaces
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

799. Heat Treating Furnaces
Folder on industrial furnaces. Continuous designs. *Pacific Industrial*

800. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

801. Heat Treating Supplies
Data sheets on carburizing, hardening, tempering, nitriding salts, metal cleaning and rust prevention materials. *Heatbath*

802. Heat Treating Supplies
New bulletin on formed and welded alloy heat treating furnace fabrications. *Alloy Engineering Co.*

803. Heaters
New Bulletin L-1244 on Chromalox stud heaters. How to use and table of sizes, ratings and prices. *Edwin L. Wiegand Co.*

804. Heating Element
New 12-page catalog on 35-20 nickel-chromium-iron heating element. Temperature-resistance curve, physical property tables and factors to consider in designing furnace elements. *Hoskins Mfg. Co.*

805. High-Strength Steel
New 4-page bulletin on Yoloy "E" steel. Properties, corrosion resistance and strength. *Youngstown Sheet & Tube*

806. High-Strength Steel
Data sheet and 16-page folder on Vasco-Jet 1000, 5% chromium air hardening steel. Mechanical properties, fatigue strength, heat treatment and surface properties. *Vanadium-Alloys Steel Co.*

807. High-Temperature Alloy
14-page bulletin on Udimet 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica Metals Div.*

808. High-Tensile Steel
New 12-page bulletin on properties and composition of N-A-X high-tensile steel. Examples of resistance to impact, fatigue, abrasion and corrosion. *Great Lakes Steel*

809. Hot-Working Steels
New 10-page pamphlet on hot-working steels. Composition, machining and inspection, heat treatment. Properties, applications. *Marathon Specialty Steels*

810. Induction Heating
12-page bulletin gives descriptions, technical data on various sizes. Water systems diagrammed, and standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

811. Induction Heating
New 12-page Bulletin 12B6430B on high-frequency induction heating. Specifications, applications, accessories. *Allis-Chalmers*

812. Induction Heating
Need for ground detectors on high frequency induction furnace discussed in Inducto Metal Melting Newsletter, No. 5. *Inductotherm*

813. Induction Heating
36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

814. Induction Heating
New 12-page Bulletin HF-58-6 on high frequency induction heating equipment. Heat treating, annealing, brazing, forging, shrink fitting data. *Magnethermic*

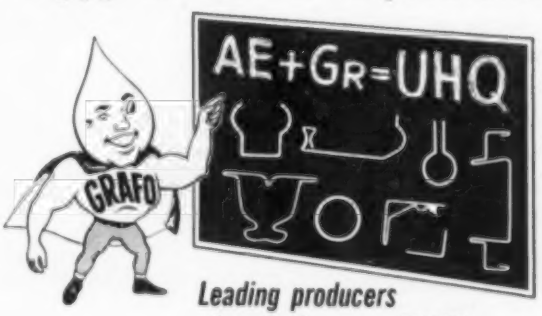
815. Induction Heating
8-page catalog secton 22C on induction heating for forming and forging. Advantages of induction heat. *Ohio Crankshaft*

816. Induction Heating
Brochure on induction heating furnace. Frequency chart. *Pittsburgh Induction Heating Co.*

817. Induction Heating
Bulletin SK-4897 on inductor-type motor-generator sets for induction heating and melting. Electrical characteristics. *Star-Kimble Div., Safety Industries, Inc.*

818. Inspection
16-page catalog on illuminated Borescopes for industrial inspection of deep recessed areas. *National Electric Instrument Div.*

Happy answer to a problem!



Leading producers of extrusions use GRAFO

Many manufacturers of aluminum extrusions already know the basic answer. It's simply this: *Aluminum Extruding* plus *GRAFO* equals *Uniformly High Quality!*

Why? Because GRAFO Colloidal Graphite dispersed in water reduces die wear, prevents sticking, gives better metal flow and improved production. *Send for booklet "The Biggest Ounce of Protection"*

•If you have a problem of excessive temperatures, pressures or abrasion, let us help you solve it with a GRAFO Water, Oil or Alcohol Dispersion for your conditions.

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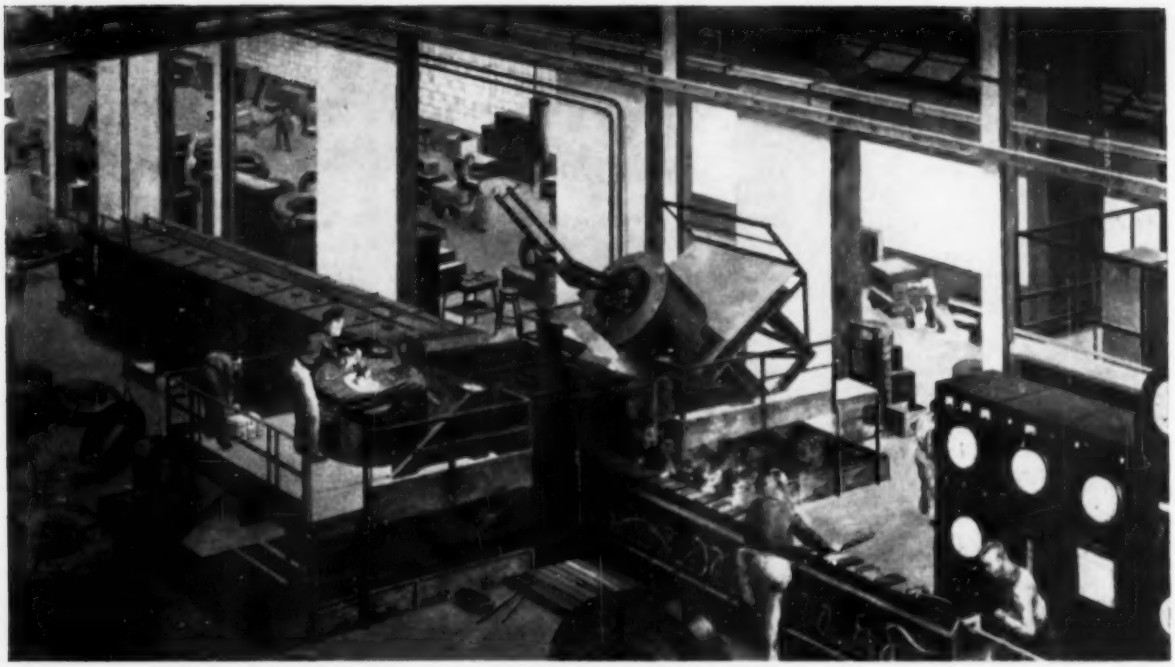
279 Wilkes Place, Sharon, Pa.



60 CYCLE INDUCTION MELTING OF HIGH LEADED BRONZES

15 years ago, THE CLEVELAND GRAPHITE BRONZE COMPANY, division of CLEVITE CORPORATION, pioneered 60 CYCLE INDUCTION MELTING of bronzes with up to 35% lead. Special furnaces developed by AJAX for this difficult job are an important element in their unique continuous production line for steel-backed bronze bearing strip. 60 CYCLE INDUCTION MELTING furnaces resulted in substantial improvements and cost savings over gas-fired units used earlier for that purpose. Today, CLEVITE operates six continuous lines in this country and abroad with AJAX 60 CYCLE INDUCTION MELTING furnaces, producing enough strip to make 130 million bearings and bushings per year.

The heavy duty 60 cycle inductor developed by AJAX and pioneered by CLEVITE will attain a lining life of one year with bronzes of substantial lead content. Electromagnetic stirring assures uniform alloy and close temperature control. Compared to externally fired equipment, metal loss savings run into many thousands of dollars per year. Recently, several large producers of leaded bronze castings converted their foundries entirely to 60 CYCLE INDUCTION MELTING.

While this is one of the most difficult metals to handle, the advantages of 60 CYCLE INDUCTION MELTING stand out today wherever copper alloys are melted. As specialists in 60 CYCLE INDUCTION MELTING, we have developed furnace types to best fill each application.

We invite you to discuss your melting problems with us at the NATIONAL METAL SHOW, CLEVELAND, Oct. 27-31, BOOTH 1608

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ENGINEERING CORPORATION

TRENTON 7, NEW JERSEY

60 CYCLE INDUCTION MELTING

Associated Companies: Ajax Electrothermic Corporation Ajax Electric Company

819. Inspection
Data on multi-frequency inspection of nonferrous and nonmagnetic metals. *Magnetic Analysis*

820. Instruments
New 60-page Catalog 500 on supplies and accessories for instrument users. *Foxboro*

821. Instruments
New Bulletin D on thermowells. Types and alloys in which they are available. Specifications in chart form. *Thermo Electric*

822. Laboratory Equipment
Folder on 5 types of laboratory mixers. Specifications for each type. *Mixing Equipment*

823. Laboratory Equipment
New bulletin on cutting test specimens describes methods for different types of metals. Price list. *Sieburg Industries*

824. Laboratory Equipment
Bulletin on high-purity graphite powder, funnels, crucibles, boats. *United Carbon Products*

825. Laboratory Furnaces
Bulletin 1016 on single and dual tube furnaces for combustion analysis. *Sentry*

826. Leak Detectors
New 12-page Bulletin GEA-6817 on leak detectors for pressure and/or vacuum applications. Specifications, uses. *General Electric*

827. Low-Temperature Treatment
Data sheets and case histories of stability achieved in metals by chilling at −130 to −150° F. Effect on further processing. *Harris Refrigeration*

828. Lubricant
Bulletin 425 on colloidal dispersions for use in metal casting. Best formulas for achieving high lubricity and wetting action. *Acheson Colloids*

829. Lubricant
New 8-page Bulletin 304 on use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Molykote*

830. Lubricant
8-page booklet, "Biggest Ounce of Protection", tells of lubrication with colloidal graphite products. *Grafo Colloids*

831. Magnesium
New 53-page book on wrought forms of magnesium. Includes 44 tables. *White Metal Rolling & Stamping Corp.*

832. Manganese
9-page article on electromanganese. Manufacturing procedures, product characteristics, uses. In Foote Prints, V. 28, No. 2. *Foote Mineral Co.*

833. Melting Furnace
6-page folder R-53 on 60-cycle combined melting and holding furnace for continuous casting of aluminum. *Ajax Engineering*

834. Metal Powders
Brochure on tungsten and molybdenum powder and granules, zirconium wafers and other refractory metal products. *Metals & Residues, Inc.*

835. Metal Sorting
Data on nondestructive sorting tool for raw, semi-finished or finished parts. *J. W. Dice*

836. Metallizing
Folder on types, sizes and prices of metallizing wires. *Spra Rod Corp.*

837. Metallograph
8-page catalog E-240 on research metallographic equipment discusses microscope unit, illuminator, optical equipment, camera, focusing arrangements. *Bausch & Lomb*

838. Microscope
New bulletin CM2990 explains how objects can be brought onto optical axis without altering height of stage. How to focus in 1 micron graduations. *Cooke Metallurgical Microscopes*

839. Microscope
New Technical Bulletin HHS-2 on vacuum heating stage which permits specimens to be examined at temperatures ranging from room temperature to 2000° F. *Unitron Instrument Div.*

840. Microscopes
New 8-page Bulletin SB2200-1157 on metallurgical microscopes. Accessories. *American Optical*

841. Molybdenum
8-page reprint on arc-cast molybdenum describes machining procedures, tools and equipment. How to machine a turbine wheel. *Climax Molybdenum Div.*

842. Molybdenum
24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

843. Nickel Alloys
38-page catalog on Monel, Inconel, nickel and nickel clad copper. Includes properties, applications and technical data. *Riverside-Alloy Metal*

844. Nickel Chromium Steels
8-page bulletin with 28 charts on composition, heat treatment, transformation characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

845. Nondestructive Inspection
8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection and its uses. *Sperry Products*

846. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

847. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

848. Oil Products
New 12-page booklet on rust preventives, lubricants, processing aids and their Government specification number. *E. F. Houghton*

849. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

850. Oil Quenching
Catalog FB-1052-A on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

851. Optics
Catalog on optics for industry. Comparators, lenses, prisms, microscopes, magnifiers. *Edmund Scientific*

852. Ore Beneficiation
New 12-page brochure on new direct reduction and beneficiation process for iron. Ores treated, testing method and licensing procedures. *R-N Corp.*

853. Ovens
Bulletin No. 5720 on mechanical recirculating utility ovens with automatic temperature control. *Blue M Electric*

(*Continued on page 48-A*

McDANEL Mullite Combustion Tubes

GAS-TIGHT! STRAIGHT! RESIST THERMAL SHOCK!

Low coefficient of expansion with maximum thermal shock resistance. High accuracy bore, exact wall thickness. Open end precisely ground for perfect stopper fit.

McDanel Mullite Combustion Tubes are recommended for service temperatures up to 2,900 degrees F. Straight or tapered ends, or self-cooling (double-reduced) design.

McDANEL Industrial CERAMICS

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS . PENNSYLVANIA

Write Today for Bulletin C1-55 on McDanel Combustion Tubes and Accessories.

Don't throw away those epoxy-coated rejects

Here's a new paint stripper that will save them

Do you scrap perfect metal parts that have been imperfectly coated with epoxies, vinyls, polyesters and other hard-to-strip paints or lacquers?

In the last few months, users of Oakite Stripper S-A have eliminated many such losses. Here's what some of them say about it:

CALIFORNIA: An aircraft manufacturer tested many strippers on an epoxy designed to resist attack by hydraulic fluid. Finally found that Oakite Stripper S-A is "the only one that safely strips this paint from anodized aluminum."

NEW YORK: A camera maker coats flash bulb reflectors with black vinyl paint outside and aluminum paint inside. "Stripper S-A is the fastest ever used on our rejects."

OHIO: A maker of toy pistols had trouble stripping alternate coats of lacquer and metallized aluminum. Now "Stripper S-A does it amazingly fast and remetallizing is completely satisfactory."

CALIFORNIA: A producer of metal furniture uses Stripper S-A to remove clear epoxy from plated parts. Chemist says "This is the best stripper on the market."

ALABAMA: A hardware maker had trouble stripping lacquer from brass door knobs. Oakite Stripper S-A now does the work in "less than ⅓ the time taken by any other stripper."

NEW YORK: A manufacturer of business machines tested several strippers on various finishes on steel and aluminum. Verdict in favor of Stripper S-A was: "It's doing a wonderful job."

CONNECTICUT: A maker of brass lipstick shells has found that "Stripper S-A quickly strips epoxy lacquers from rejects and heavily coated work spindles."

CALIFORNIA: A missile maker reports that "Stripper S-A is doing a fine job stripping vinyl from stainless steel and titanium."

FREE Write Oakite Products, Inc., 26 Rector St., New York 6, N. Y., for complete information on Oakite Stripper S-A.

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New Star Performer In The Sandvik Line

SANDVIK

Presents A SUPER SPRING STEEL

Sandvik's new 2R25 is a superior grade of stainless spring steel which goes far beyond the capabilities of ordinary spring steels. It was developed for applications where performance outranks cost.

This new steel is a prime example of Sandvik's ability to combine several advantageous properties in one metal.

Mechanical Data on 2R25 —

TENSILE STRENGTH RANGE — Hard Rolled 242,000 • 270,000 or 299,000 PSI
Heat Treated 270,000 • 299,000 or 327,000 PSI

ELASTIC LIMIT (.01% Proof Stress) — From 156,000 to 192,000 PSI according to size and finish

Sandvik 2R25 is exceptionally tough and resilient, much more formable than hardened and tempered steel, has up to 10 times the fatigue life of ordinary carbon spring steel and has excellent corrosion resistance under varying atmospheric conditions.

MODULUS OF ELASTICITY — 27.7 to 35.6 x 10^6 PSI according to size and finish

SIZES (with extremely close tolerances)
Thickness — .0016" to .035"
Width — .039" to 3.94"

For further information on Sandvik 2R25, contact your nearest Sandvik office

Sandvik stocks a wide variety of qualities and sizes of cold rolled specialty strip steels. In addition Sandvik has rolling, slitting, edge-filing and hardening and tempering facilities. *Send for your copy of this free brochure* which gives specific data on the leading types of Sandvik steels.

Hardened & Tempered Spring Steel

Annealed Spring Steel

Band Saw Steels

Flapper Valve Steel

Piston Ring Steels

Razor Blade Steel

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"B&W extrusions

simplify our production problems

We can reduce final parts cost through the use of a B&W Extrusion because it cuts machining time and eliminates waste of costly material."

Machining is expensive and wastes material. It is doubly so when it is not necessary. Design engineers should investigate the possibility of using an extruded section as starting material, particularly if expensive or difficult to machine materials such as alloy or stainless steels are involved. In many cases, by using a B&W Extrusion, parts production can be reduced to a mere cutting to length and a few simple finishing operations.

To find out more about how B&W Extrusions can help you design a better product at a lower cost call on any of the local sales offices of B&W's Tubular Products Division or write for a copy of Bulletin TB 413. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

TUBULAR PRODUCTS DIVISION

TA-8027-E1

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

(Continued from page 45)

854. Perforated Metals
156-page catalog on what materials are perforated, where perforated sections are used and what perforation patterns are available. *Harrington & King Perforating*

855. Phosphating
Folder on phosphating and metal protective coating materials. Purpose and make-up of each type of coating. *Turco*

856. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

857. Plating
12-page bulletin on anodes, anode accessories and chemicals for electroplating and finishing. *Hanson-Van Winkle-Munning*

858. Plating
9-page bulletin on copper fluoborate bath for printed circuits. Bath composition, make-up and control for copper and tin plating. *Baker & Adamson.* See page 173.

859. Plating
8-page brochure on test equipment for plating baths. Controls, anodes, cathodes, agitators, rectifiers. *R. O. Hull*

860. Plating
Data and specification sheet covering tin plating a wide range of nonferrous thin strip metals. *Somers Brass Co.*

861. Plating Thickness
Metal Digest V, 3, No. 2, on sample preparation and optical measurement of plating thicknesses. *Buehler, Ltd.*

862. Powdered Metals
New Bulletin No. 1200 on 50-ton multiple-motion powder metal press. Operating characteristics, physical specifications. *F. J. Stokes*

863. Precision Casting
16-page booklet on methods used to produce castings by the "lost-wax" method. Compositions of alloys used. *Crucible Steel*

864. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

865. Press
Bulletin 380 on powdered metal press. Description, operation, specification. *Watson-Stillman Press Div.*

866. Pyrometer Supplies
56-page bulletin P1238 on thermocouples and pyrometer accessories. Engineering data on selection and installation. *Bristol*

867. Quenching
16-page booklet on modified and full marquenching procedures. Hardness and dimensional control data, cooling curves, case histories. *Sinclair Refining Co.*

868. Quenching
Data sheet 29 on quenching oil includes data on effect of agitation, advantages and specification. *Sun Oil*

869. Radiation Products
8-page catalog on equipment for nuclear research. Radioactive sources, shielding and exposure equipment, instruments, services. *Budd Co.*

870. Radiography
28-page booklet on products for industrial radiography gives exposure and processing data for various film used. *DuPont, X-Ray Div.*

871. Radioisotopes
8-page booklet on cobalt-60, cesium-137, iridium-192 and how they are used in radiography. Gamma and X-ray radiography compared. *Ansco*

872. Refractories
8-page catalog of super refractory shapes, tubes, insulators for use to 3500° F. *Morganite, Inc.*

873. Refractory Metals
Booklet on tungsten, molybdenum, tantalum, their properties and uses. *Fansteel Metallurgical*

874. Resistance Material
16-page brochure on high-temperature electrical resistance heating material. Electrical, chemical and physical characteristics of new cermet material. *Kanthal*

875. Resistance Welding
24-page catalog on equipment for resistance welding includes reference tables and property and application charts. *Ampco*

876. Rhodium Plating
New 20-page booklet on rhodium plating processes. Advantages, applications. *Sel-Rex Corp.*

877. Rhodium Plating
Data on rhodium sulphate and on limited time tests of this rhodium concentrate. *Technic*

878. Rolling Mills
New Catalog FRM-58 on mills for laboratory and development. Wire flattening. Accessories. *Fenn Mfg.*

879. Rust Prevention
Nine bulletins in one folder on rust prevention. Theory of corrosion. Applications. *Production Specialties*

880. Rust Preventive
New bulletin on wetting agent and emulsifier for use as a rust preventive and corrosion inhibitor. *Swift & Co.*

881. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

882. Shear
Bulletin on bar and billet shear for rounds, squares, flats, billets and structurals. Hot or cold operation. *Hill Acme*

883. Shell Molding
New 4-page Data Sheet SF-1128 on silicones for the shell molding process describes three different products. *Silicones Div., Union Carbide*

884. Shot and Grit
14-page catalog describes cast steel, malleable iron, chilled iron, cut wire and other forms of abrasive shot and grit. Methods of shot peening and impact cleaning. *Abrasive Shot & Grit*

885. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *National Metal Abrasive*

886. Slitting
New 48-page Bulletin 571 on rotary slitting knives, trimming knives, pipe and tube cut-off knives and others. Standard and special types of high speed steel and carbide tipped milling cutters. *Cowles Tool Co.*

887. Sodium
28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. *Ethyl Corp.*

888. Spectrography
From Jarrell-Ash Newsletter No. 2, June, 1958 an article on an improved method for direct reading analysis of wear metals in lubricating oil. *Jarrell-Ash*

889. Spray Painting
New 6-page booklet on airless spraying. How it works, advantages. *Nordson*

890. Spring Steels
6-page folder gives applications, materials, finish and size range. Analyses. *Sandvik Steel*

891. Stainless Castings
Bulletin on advantages of corrosion-resistant castings. *Ohio Steel Foundry*

892. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

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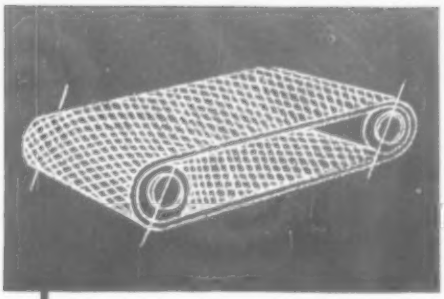

STEP UP OUTPUT | **KNOCK DOWN COSTS**

The key word in heat treating today is automation—the handling of stock smoothly, efficiently, without waste. Obvious benefits are boosted production and slashed costs.

Holcroft's answer to automation may be conveyorized furnaces—automatic, not only in stock handling, but with automatically-controlled cycles, too. Each Holcroft installation is custom-engineered to do your job *at the lowest possible cost.*

Conveyor furnaces are almost unlimited in style and application. Single or multi-strand conveyors can be equipped with mesh belts, sheet belts, interlocking links, monorails or pusher chains. Direction of flow can be horizontal, vertical, or in combination—whichever affords the most economic use of available space. Some conveyors are completely inside the furnace—others are integrated into the production line.

All other types of stock-handling furnaces are available from Holcroft, too. So for a furnace designed with your specific heat treating requirements in mind, Holcroft is your best bet, by far.

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& COMPANY

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DETROIT 10, MICHIGAN
PRODUCTION HEAT TREAT FURNACES
FOR EVERY PURPOSE

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

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BARBER COLMAN

Wheelco Instruments

Outstanding control accuracy provided for furnace temperatures topping 3600° F

Wheelco Heat Eye and Model 8000 recorder-controller maintain precise temperatures in research furnace.

This special molybdenum rod resistance furnace, capable of reaching temperatures above 3600° F in a hydrogen atmosphere, was built by CM Inc., Bloomfield, N. J., for a large industrial research center. Furnace is controlled by using the Wheelco Heat Eye radiation detector and a Model 8000 recorder-controller.

Wheelco instruments are specified on this furnace, and on similar units built by CM Inc. for processing ceramics and other materials in controlled atmospheres, because they provide the outstanding accuracy that is mandatory in ultra-high-temperature processing. Where permanent process records are not required, Wheelco 400 Series indicating controllers can be used in place of the 8000 Series units.

If you aren't already using Wheelco instrumentation to control high-temperature processing, then your nearby Wheelco field engineer is the man you should meet. His analysis of how your instrumentation efficiency can be improved is available without obligation.

BARBER-COLMAN COMPANY

Dept. V, 1518 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. H, Toronto

893. Stainless Steel

12-page bulletin on chromium-manganese austenitic steel. Effect of cold working, properties at elevated temperatures, corrosion resistance, magnetic permeability. *U.S. Steel Corp.*

894. Stainless Steel

16-page booklet on Type 430 stainless gives physical properties and analysis, corrosion resistance, fabrication, application and care. *Washington Steel*

895. Stainless Strip

32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties, corrosion resistance. *Superior Steel*

896. Stainless Tubing

12-page brochure on stainless steel heat exchanger and condenser tubes. Manufacture, chemical composition and analysis. *Republic Steel*

897. Steel

New 22-page manual on aluminized (aluminum coated) steel Type 2. Corrosion resistance, mechanical properties, uses, advantages. *Armco Steel*

898. Steel Terms

32-page dictionary of terms used in the steel industry. 180 definitions. Equilibrium diagrams, tables, figures. *LaSalle Steel*

899. Steel Tubing

48-page Handbook F-3 on fabricating and forging steel tubing. Bending, shaping, cutting and joining operations described. *Ohio Seamless Tube*

900. Strip Mill

Data on cold reduction mill. *Loma Machine Mfg. Co.*

901. Temperature Control

8-page bulletin on temperature control systems contains selection guide, terminology, types of control systems. *Wheelco*

902. Tempilstiks

"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

903. Tester

New Bulletin 9E on universal tester. Specifications, principle of operation. *W. C. Dillon & Co.*

904. Testing Machines

12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

905. Thermocouples

32-page file book on pyrometer accessories. Selection of thermocouple and protective tube. *West Instrument*

906. Thermostatic Bimetal

44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

907. Thickness Gage

Folder on pocket-size gage. How to use it. *Ferro Corp.*

908. Thickness Testing

10-page bulletin 2253 on coating thickness gages. Standard and special purpose gages. *American Instrument*

909. Tin News

Interesting monthly report covers important current developments in the production, marketing and use of tin. *Malayan Tin Bureau*

910. Titanium

New 8-page booklet on corrosion resistance of titanium. Table of ratings of titanium compared with zirconium, tantalum and stainless in various mediums. *Mallory Sharon*

911. Titanium Alloy

12-page booklet on C-120AV titanium alloy. Physical properties, elevated-temperature properties, creep, fatigue, welding, machining, heat treatment. *Rem-Cru*

912. Tool Steel

Fourth edition of the 204-page handbook. Types, properties and applications of tool steels. Selection, tool steel products, and working tool steels and high speed steels. *Allegheny Ludlum*

913. Tool Steel Selector

Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

914. Tool Steels

New 44-page Stock List No. 13 is indexed and includes sizes, weights and analyses. Decimal conversion and hardness conversion. *Uddeholm*

915. Tubing

New 6-page Technical Bulletin TB-418 on mechanical tubing. Tolerance tables. Applications. *Tubular Products Div., B. & W.*

916. Tubing

New 60-page handbook on cold drawn buttweld mechanical steel tubing. 75 photos and drawings explain production, finishing, inspection. *Pittsburgh Tube*

917. Tubing

64-page handbook on use of tube mills in manufacture of pipe and tube. Step-by-step description of the electric-weld process. *Yoder*

918. Ultrasonics

Data sheets on high-power ultrasonic generators for mass production and ultrasonic cleaner. *Acoustica Associates*

919. Ultrasonics

Data sheet on gages for thickness measurement, coating measurement, inspection. *Branson Instruments*

920. Ultrasonic Cleaners

New Bulletin UL-101 on industrial ultrasonic cleaners. Advantages, applications, general specifications. *Gulton Industries, Inc.*

921. Vacuum Casting

Booklet on vacuum-cast superalloy ingots and investment castings. *Kolcast Industries*

922. Vacuum Furnace

New folder on vacuum button furnace with multiple button hearth for high-purity melts. *Zak Machine Works*

923. Vacuum Valves

32-page manual on high-vacuum valves. Requirements for high-vacuum service, sizes, materials. *NRC Equipment*

924. Welding Electrodes

Report No. W5410 on low hydrogen electrodes for high alloy steels. *Harnischfeger*

925. Welding Stainless

New 12-page booklet—a guide to better welding of stainless steels. In question and answer form. *Arcos*

926. Wire Mesh Belts

130-page reference manual on mesh specifications, design, metallurgical data. *Cambridge Wire Cloth*

927. Wire Straightening

20-page brochure on wire straightening and cutting machines, wire reels, chamfering and deburring machines. New air clutch described. *Lewis Machine Co.*

928. X-Ray Diffraction

4-page bulletin on X-ray diffraction for research, production control. Two units described. *General Electric, X-Ray Dept.*

929. Zinc Coating

8-page booklet on zinc-coated steel sheets. Fabrication, uses, advantages in heating, ventilating and air conditioning. *Weirton Steel*

930. Zirconium

8-page brochure on zirconium's corrosion resistant properties. Applications based on this property. *Carborundum Metals Co.*

931. Zirconium

18-page pocket-sized book on manufacture, properties, metallography, machining, metal powders. Extensive bibliography. *Titanium Alloy Mfg. Div.*

October, 1958

651	676	701	726	751	776	801	826	851	876	901	926
652	677	702	727	752	777	802	827	852	877	902	927
653	678	703	728	753	778	803	828	853	878	903	928
654	679	704	729	754	779	804	829	854	879	904	929
655	680	705	730	755	780	805	830	855	880	905	930
656	681	706	731	756	781	806	831	856	881	906	931
657	682	707	732	757	782	807	832	857	882	907	
658	683	708	733	758	783	808	833	858	883	908	
659	684	709	734	759	784	809	834	859	884	909	
660	685	710	735	760	785	810	835	860	885	910	
661	686	711	736	761	786	811	836	861	886	911	
662	687	712	737	762	787	812	837	862	887	912	
663	688	713	738	763	788	813	838	863	888	913	
664	689	714	739	764	789	814	839	864	889	914	
665	690	715	740	765	790	815	840	865	890	915	
666	691	716	741	766	791	816	841	866	891	916	
667	692	717	742	767	792	817	842	867	892	917	
668	693	718	743	768	793	818	843	868	893	918	
669	694	719	744	769	794	819	844	869	894	919	
670	695	720	745	770	795	820	845	870	895	920	
671	696	721	746	771	796	821	846	871	896	921	
672	697	722	747	772	797	822	847	872	897	922	
673	698	723	748	773	798	823	848	873	898	923	
674	699	724	749	774	799	824	849	874	899	924	
675	700	725	750	775	800	825	850	875	900	925	

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7301 Euclid Avenue, Cleveland 3, Ohio

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Title _____

Company _____

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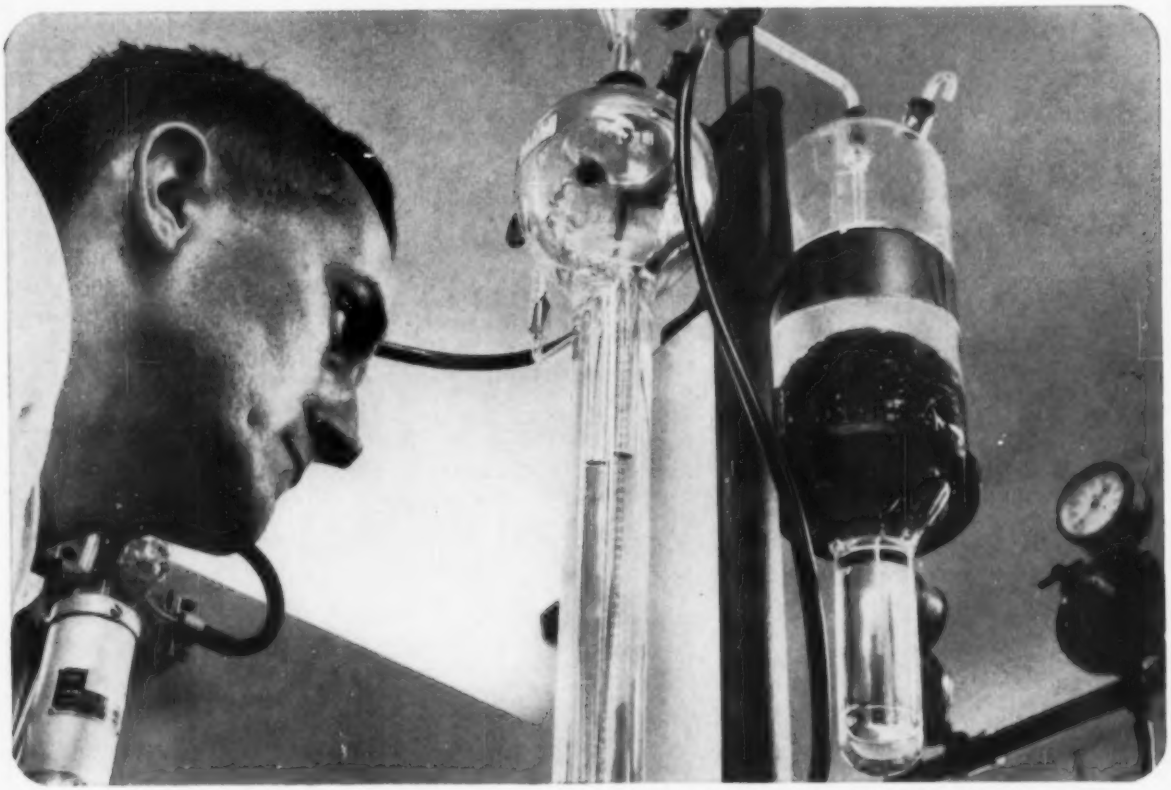
City and State _____

Postcard must be mailed prior to Jan. 1, 1959
Students should write direct to manufacturers.

Experience—*the added alloy in* ***Allegheny Ludlum*** *tool steels*



QUICK, FAST TESTING for carbon content is done not once or twice but 8 times per melt in A-L's Chem Lab with this direct reading Leco carbon determinator.

Carbon content checked 8 times during melt to guarantee A-L tool steel hardenability

Lab tests for carbon eliminate your guesswork; provide high hardness, uniform hardenability, reproducible tool performance.

Because carbon has the greatest influence on hardenability, Allegheny Ludlum watches it carefully during the melt. Testing a specimen for carbon takes only a few minutes. Therefore, A-L checks for carbon content 8 times during the melt, and makes the necessary adjustments to insure accurate control of carbon. This control means Allegheny Ludlum can hold carbon content to a closer range than most customers specify.

Carbon control at Allegheny Ludlum assures you of precise response to heat treating. This control in the melt brings you predictable, *high hardness, uniform hardenability* and *reproducible tool performance.*

This is just one of the many things A-L does to insure high quality. Here are some others: close control over forging techniques, rigid temperature-time programming, careful testing of billets prior to processing to insure good surface and sound interior, control over annealing to give you the right hardness for your exact machining operation, thorough metallurgical testing to insure top tool steel quality and meeting of your specifications.

Allegheny Ludlum stocks a complete line of tool steel sizes and grades. Call your nearest A-L representative; you'll get quick service and counsel on such problems as heat treating, machining, grade selection, etc. Or write for A-L's publication list which gives full data on the more than 125 technical publications offered. They'll make your job easier.

ALLEGHENY LUDLUM STEEL CORPORATION, Oliver Bldg., Pittsburgh 22, Pa. Address Dept. MP-10

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Tool Steel warehouse stocks throughout the country... Check the yellow pages

every grade of tool steel... every help in using it

April—Ammonia storage tank installed without supervision by supplier "Z"...

Later—Leaks! Getting improper flow of ammonia . . .

Still later—Discovered certain vital equipment improperly installed . . .

Too late—Safety and efficiency at danger point, shut down line to make repairs . . .

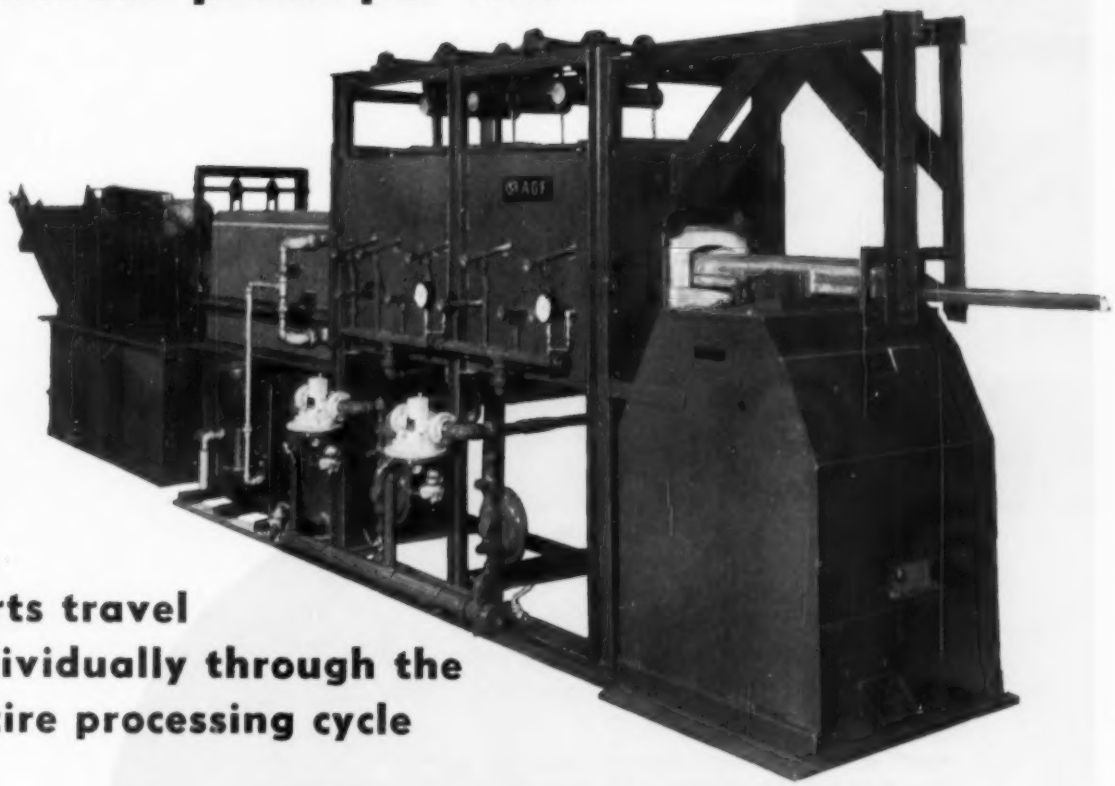
Be trouble-free—be sure Armour Ammonia experts help supervise <u>your</u> cylinder and storage tank installations!

Armour's Technical Service plus a consistent purity of 99.98%—on delivery—from 163 stock points and 8 bulk stations make Armour your one best source for trouble-free ammonia. For further information on cylinder or storage tank installations, write us on your company letterhead.

ARMOUR AMMONIA DIVISION

1353 West 31st Street • Chicago 9, Illinois

Consistent Uniformity as you Bright Harden and Bright Anneal at 1850° — 100 pounds of stainless parts per hour!



Parts travel individually through the entire processing cycle

This new Shaker Hearth employs an alloy muffle which incorporates a purging, heating and water-jacketed cooling section, and seals into an automatic conveyorized oil tank.
Among the many operational advantages of this new line of Reciprocating Furnaces, are the maintenance of —80° to —90° F. dew points . . . complete atmosphere uniformity throughout the processing cycle . . . and a very low consumption of atmosphere gas . . . Batch purging, heating and cooling are eliminated . . . and the parts may be observed throughout the entire processing cycle through openings in the charge and discharge ends of the muffle.

Write for Equipment Catalog #8A.

AMERICAN GAS FURNACE CO.
1002 LAFAYETTE STREET — ELIZABETH 4, N. J.
"Pioneers since 1878"

Be sure to see our latest improved machine at Booth No. 2027, Cleveland Metal Show, Oct. 27-31

Radiographer Harold B. Allen of TWA, shown on the wing of a TWA Constellation, is placing the x-ray machine in position to check the lower wing skin of the inboard engine nacelle.

"For critical aircraft inspection,

TWA uses Du Pont x-ray film"

reports Mr. Norman W. Grotz, Manager of Inspection at Trans World Airlines Overhaul Base in Parkville, Missouri

Each TWA airliner is fully inspected after each 3000 hours of flight time to conform to TWA safety requirements. The use of x-ray has enabled TWA to save approximately 150 man-hours per major overhaul and has made it possible to accurately check structural integrity of areas invisible with other methods.

Most of the film used at the Parkville Overhaul Base is Du Pont x-ray film. Explaining why, Mr. Grotz says, "We tested all available x-ray films to determine their suitability. Du Pont film met all of our stringent requirements, including fine grain for visualization of critical detail. And the service of the Du Pont Technical Representatives is excellent—an important factor in our use of this film.

"Some of the vital checks we make with Du Pont film are for foreign particles in the engine oil coolers, various hydraulic cylinders and the engine nacelles," continues Mr. Grotz. "The bottom skin of the wing, 1/8 inch aluminum, is subjected to heavy stress. With Du Pont film, we can easily check the bottom skin through four other layers of metal and feel confident about the accuracy of our findings."

Mr. Grotz is in charge of inspecting each of TWA's 135 Constellations. "By combining technical know-how," he concludes, "with fine equipment and materials like Du Pont x-ray film, we are daily improving our inspection procedures while maintaining TWA's fine safety record in the sky."

For quality you can depend on, with the finest technical service, use Du Pont Industrial X-ray Film. If you want more information, call the nearest Du Pont Sales Office, or write Du Pont Photo Products Department, 2432-A Nemours Building, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

DU PONT
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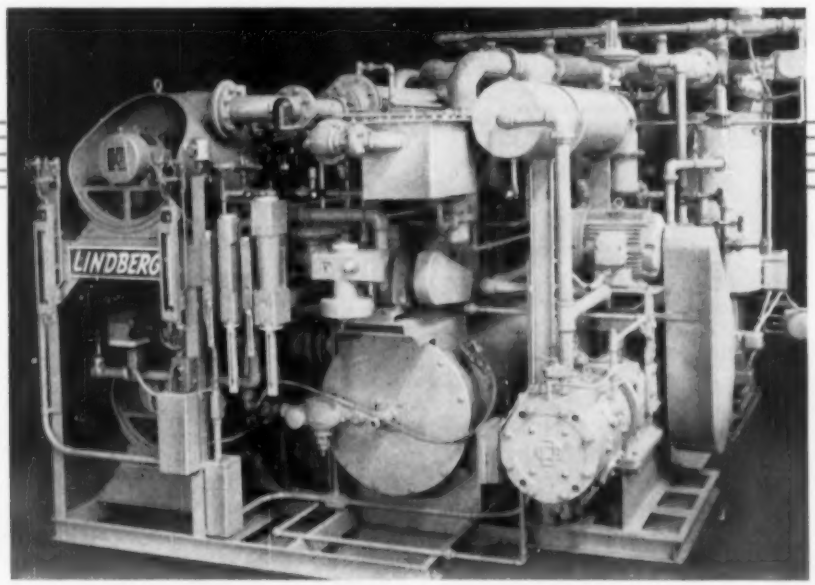
Better Things for Better Living . . . *through Chemistry*

* Atmosphere of 99.99% inert gases now provided by new Lindberg HYNI Generator

** Completely new, fully automatic, dry process provides highest degree of nitrogen purity

*** This process produces nitrogen for only $0.17 to $0.20 per 1000 cubic feet

In the metals industry this superior nitrogen atmosphere is ideal for bright hardening, free from carburization and decarburization . . . annealing and normalizing without scale, decarburization or carburization . . . bright copper and silver brazing . . . carbon correction of decarburized forgings or bar stock . . . sintering of powder metals . . . gas carburizing and carbonitriding. It is also useful as a blanketing gas in the chemical and food processing industries.



This new HYNI generator is an important addition to Lindberg's complete line of controlled atmosphere generators. Write us for complete information on this remarkable new unit, and other Lindberg generators for any required atmosphere type.

See us, too, in Booth 331 at The Metal Show

** How The Process Operates

This 99.99% pure atmosphere is produced by a completely new, dry, fully automatic process. It uses the principle of burning a hydrocarbon fuel in a separate catalytic combustion chamber to obtain complete reaction without unburned methane, high residual oxygen or a high percentage of oxides of nitrogen. Carbon dioxide, water vapor, sulphur dioxide or hydrogen sulphide are simultaneously removed in a dry, absorbent material known as Molecular Sieve made by Linde Division of Union Carbide and Chemical Corporation.

* Sample of Analysis Obtainable With HYNI Generator

Oxygen	0.00%
Carbon dioxide	0.01%
Hydrocarbons	0.00%
Water vapor: Less than -80° F. dewpoint (7 p.p.m. when measured by a Beckman Hygrometer)	
Hydrogen	0.00%
Carbon monoxide	0.00%
Sulphur	0.00%
Oxides of nitrogen	0.00%
Nitrogen and Argon	99.99%

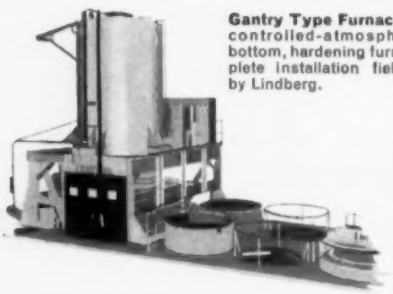
*** This Process is Economical

One of the advantages of this process of producing nitrogen is its low cost. With the HYNI Generator the nearly-pure nitrogen is produced for only $0.17 to $0.20 per 1000 cubic feet. Cost of power, raw gas and cooling water is included and based on: fuel gas at $0.60 per 1,000,000 BTU; electricity at $0.01 per KWH; cooling water at $0.05 per 1000 gal. Quoted cost does not include maintenance or amortization. Lindberg quality design and construction assures complete dependability and lowest maintenance cost.

LINDBERG GAS PROCESSING DIVISION
ENGINEERING COMPANY 2448 West Hubbard Street, Chicago 12, Illinois

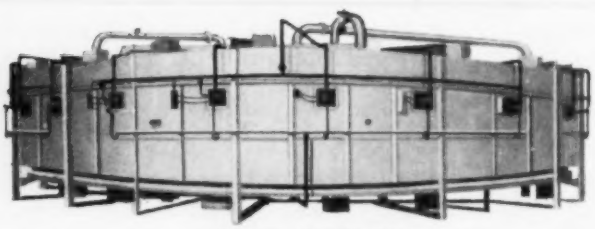
Wherever industry needs heat...

You'll find *LINDBERG* equipment just right for the specific job

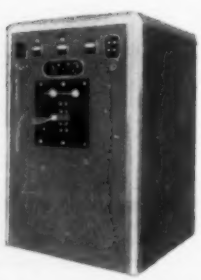


Gantry Type Furnace: Vertical, controlled-atmosphere, drop bottom, hardening furnace. Complete installation field-installed by Lindberg.

Roller Hearth Furnaces: Continuous electric type (shown) with temperature range 1300° to 2100° F.

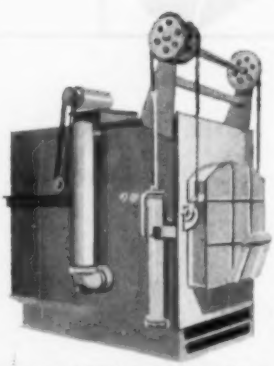


Rotary Hearth Furnaces: Doughnut type field-installed gas-fired furnace (shown) with capacity of 13,000 lbs. per hour.

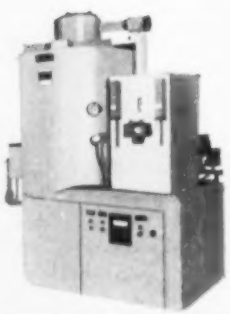


HF Induction Heating Units: Available in 5, 10, 25 and 50 KW units.

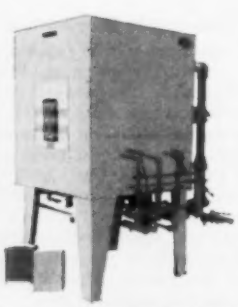
Vertical Type Furnaces: Carburizing and hardening furnace (shown) with CORRTHERM electrical heating elements.



Super-Cyclone Tempering Furnace: Production box type. Electric or gas. Two temperature ranges—to 1750° F.

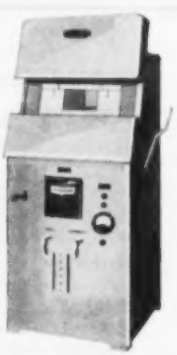


Atmosphere Generators: Hyen generator (shown) for endothermic atmospheres. Generators for all required atmospheres.

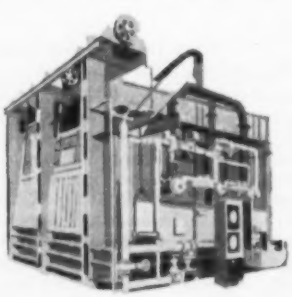


Ceramic Kilns: Gas-fired periodic kiln (shown) with temperature range to 3250° F.

Melting and Holding Furnaces: Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.



Laboratory Equipment: One-unit box furnace (shown), muffle or for non-oxidizing atmosphere with temperature range to 3000° F.



Aluminum Reverberatory Furnaces: Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.

Lindberg-Designed

heat treating installation reduces jet engine parts pickling costs 25% for Jervis

This specially designed annealing and heat treating furnace at Jervis Corporation, Grandville, Michigan, is an interesting example of how cooperation between the user and the maker of heat treating equipment can adopt established furnace principles to the improvement of production methods. Jervis and Lindberg engineers, starting with a conventional box type furnace, designed this furnace with two chambers, one for preheat and one for high heat, and added a third with a water jacket for protective cooling. This combination provides efficient heat equalization, protective atmosphere, and protects against corrosion and carbide precipitation. Jervis estimates this furnace provides a 25% reduction in pickling costs, as well as improved quality, in the treating of jet engine parts.

Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, heat treating, melting and holding, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

The handsome Jervis plant at Grandville, Michigan occupies 238,300 square feet of floor space.

Mr. James Bockheim, Metallurgist at Jervis, says, "We can handle any aircraft material in this furnace . . . and operate it with just one man."

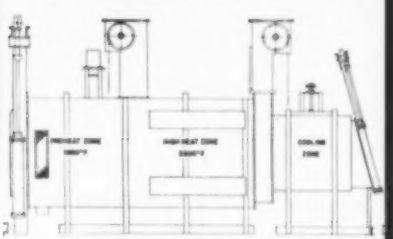


Diagram shows the unusual three-chamber furnace design.

Work coming from the cooling chamber after treatment.

Lindberg generator produces furnace atmosphere exothermically from natural gas.

★ Look up Lindberg Booth 331 at the Metal Show

LINDBERG heat for industry

ALLIS-CHALMERS

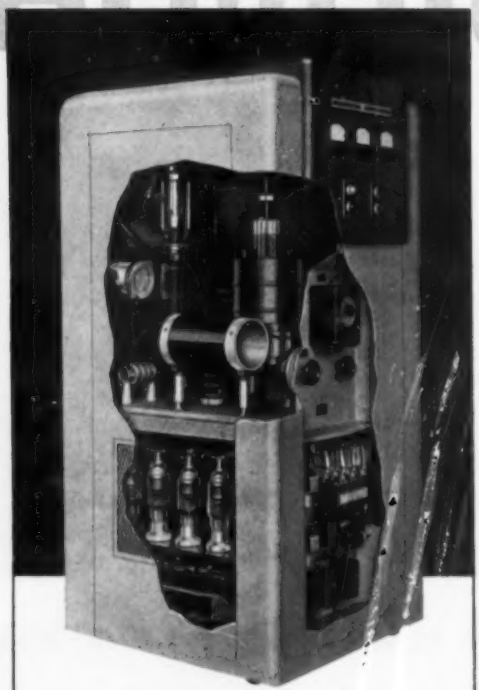
This is What Careful Buyers Want to Know about Induction Heating Equipment...

First — they want to know that they will get cost-cutting performance and dependability. This is basic... and it is the basic reason for the widespread acceptance of Allis-Chalmers induction heaters for hardening, annealing, brazing, melting.

Then — careful buyers want to know how well the equipment is backed up by the manufacturer's experience, engineering, research and service facilities. Again, Allis-Chalmers excels.

A-C engineering includes help in planning the most efficient use of induction heating in your operation, the design and manufacture of work fixtures and handling equipment, the testing of your material samples in A-C's modern laboratory. When your heater is installed, a field engineer from one of the A-C regional offices near you supervises the job.

There is an A-C representative in your area who can give you more details. Call him, or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin, for Bulletin 12B6430B.



Check These Quality Features

1. Water-cooled oscillator tube has life expectancy of 5000 hours or more — with ample reserve capacity for emergencies.
2. Plate transformer is designed for continuous, heavy-duty service... has large reserve capacity.
3. Six-tube, three-phase full-wave rectifier section is standard... choke coil and capacitor network protect rectifier tubes from high-frequency currents.
4. Compact, attractive all-steel cabinet provides electrostatic and electromagnetic shielding.
5. Output circuit is based on simple principle which eliminates need for extra, expensive output transformers.
6. Precision automatic timer and all necessary controls are standard. No extras (except handling equipment) required.
7. All operating controls are clearly marked and mounted on one panel.
8. Safety features: heavy-duty control, high water temperature switch, high and low water pressure switches, fuses, interlocked doors.

And ... Bakelite standoffs, adequate clearances, clean wiring arrangements, ceramic coils, heavy duty relays.

A-C ALLIS-CHALMERS

A-5775

The legendary Firebird, the Phoenix, rose young and strong again and again from flames . . . This is the new Norton Firebird — symbol for the exciting new fused materials made in Norton's electric furnaces.

BORON: gift of the Firebird

Comparable to the ancient Firebird legend is the wonder-working energy of Norton electric furnaces. Here, raw materials are transformed into new, high-purity compounds of tremendous importance to scientific and industrial progress.

For example, Norton began development of stable boron compounds a quarter century ago and now provides boron as the nitride, the carbide or as borides and experimentally in its elemental form.

Norton electrochemical engineering may be a valuable aid to your own processing. It enables users to improve manufacture with an increasing variety of boron-rich compounds, including intermediates for chemical processing and additives for metal alloying. Technical cooperation is available with all these *Gifts of the Firebird.*

Gifts of the Firebird: compounds of silicon • zirconium • boron • aluminum • magnesium • titanium • chromium . . . . . including many borides • carbides • nitrides • oxides.

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Write to NORTON COMPANY, Electrochemical Division, 809 New Bond Street, Worcester 6, Massachusetts.

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ELECTROCHEMICALS

MAKING BETTER PRODUCTS . . . TO MAKE YOUR PRODUCTS BETTER

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

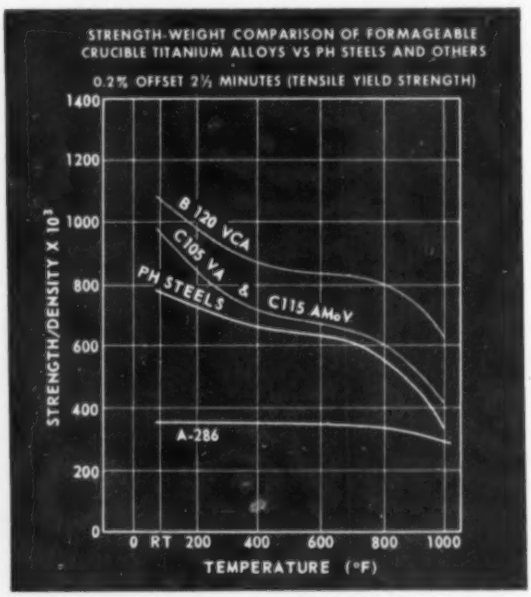
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EJ09, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:

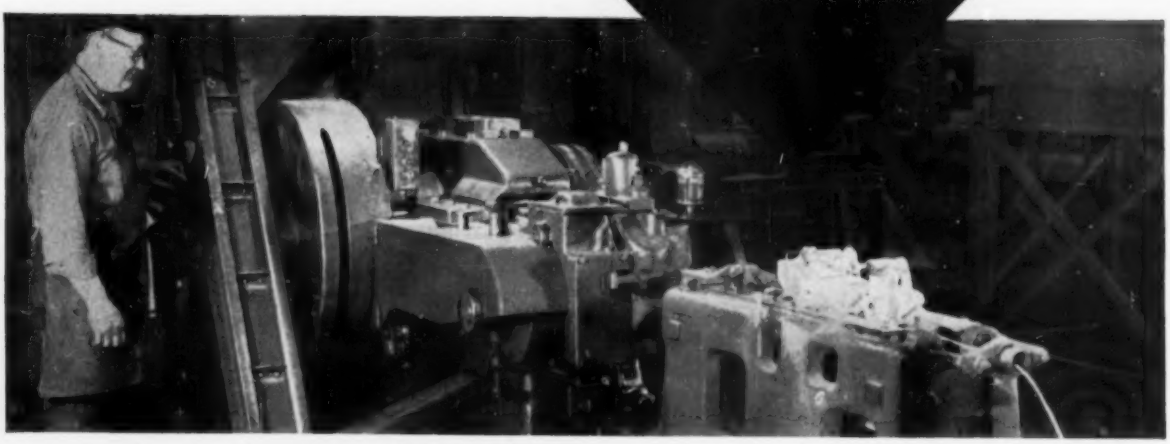
1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

*Reg. Trade Mark

MEL-TROL®
at work



You get good, predictable performance from a solid cold heading die only when the die steel you use is uniformly tough and strong through the core of the bar. But the core of the bar can only be as uniform as the core of the ingot it came from.

That's why *Carpenter* developed the MEL-TROL process. MEL-TROL uses the best quality control tools made, precise melting techniques, and an exclusive, patented ingot design, to turn out tool and die steels—such as H-9 Double Header for cold heading dies—that are more uniform through the center and have greater freedom from segregation and flaws than any other tool and die steels sold today. A call for H-9 Double Header to your nearest *Carpenter* representative—right now—is your very best answer to the problem of unpredictable performance in cold heading dies.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

MADE FOR EACH OTHER

and Your Safety

North American

Safety Shutoff Valves

Gas furnace explosions sometimes occur during light-up because someone had left open a gas burner cock after the previous shut-down, thus allowing the furnace to be filled with unburned fuel. North American Series 22 Safety Shutoff Valves and Series 1857 Cocks can be combined in a Supervising Gas Cock System to prevent such explosions.

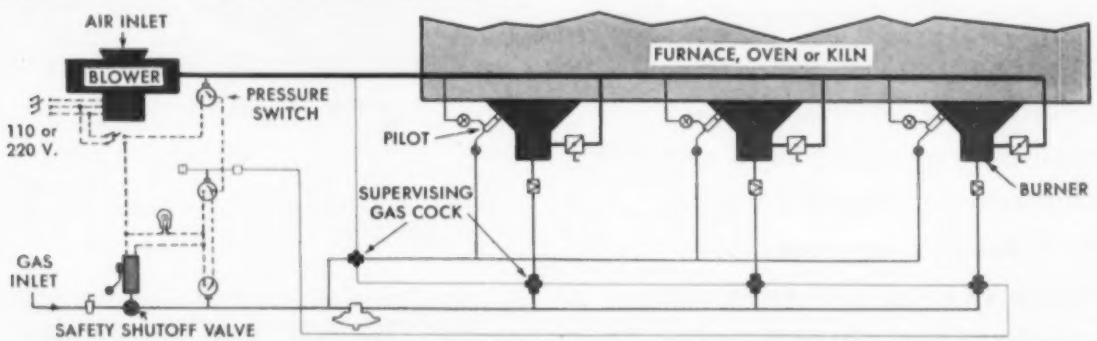
The Series 1857 Supervising Cock is drilled with a small secondary passage located so that it is open only when the main passage is closed. A checking pressure line is connected through the secondary passages of all the Supervising Cocks so that a pressure switch at the end of the line cannot close a circuit to the safety shutoff valve until all the cocks are shut. If the operator finds that he cannot open the safety shutoff valve, he must locate the open Supervising Cock and close it.

Series 22 Safety Shutoff Valves are offered in nine sizes for ¾" to 6" pipe, with solenoid or pneumatic operators, reset wheels, and companion flanges, plus provision for protection from dirty corrosive gases and weather. They are compact in design and can be installed in a variety of positions. The globe-type valve with soft seat assures positive shutoff. Approved by Factory Mutual, Underwriters' Laboratories, and Canadian Standards Association.

and

Supervising Gas Cock Systems

Series 1857 Supervising Gas Cocks are offered in fourteen sizes for ¼" to 6" pipe.



For engineering information consult your nearby N.A. office or write for Bulletin 1857.

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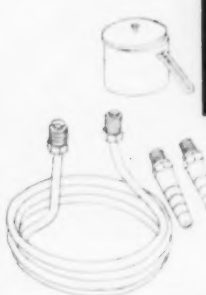

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Buehler Ltd.

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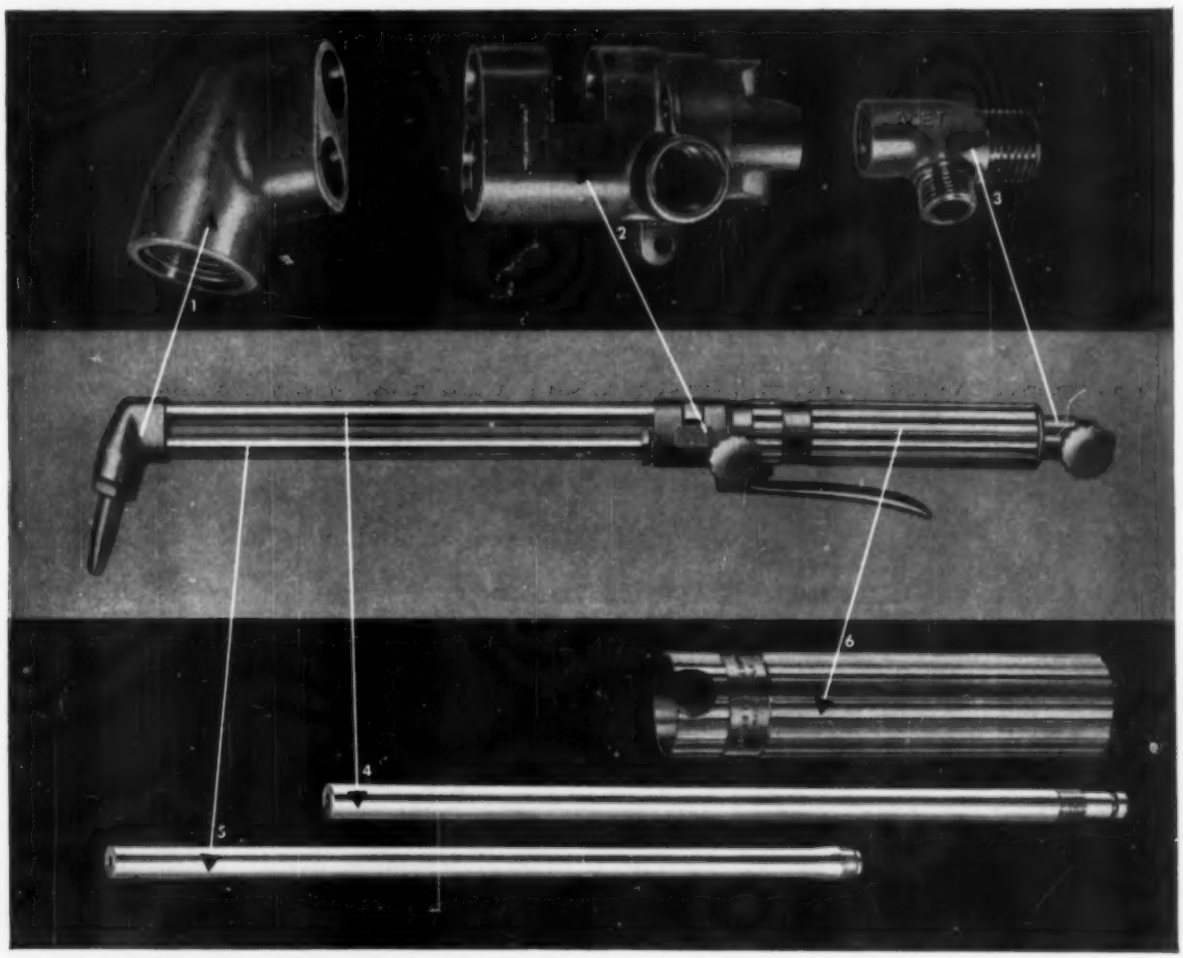
SHORT CUTS to finished products.

Anaconda pre-formed mill products cut time and cost in finishing and machining—reduce scrap losses.



Linde Company's "Purox" Cutting Blowpipe, Type "E," is produced more easily and economically with these Anaconda products. **1, 2, 3.** Die-pressed forgings, with these advantages: twice-wrought metal has denseness to prevent gas leaks; toughness and strength to stand up to abuse; has uniformity, dimensional accuracy to cut machining cost—finishing reduced to bright dip. **4, 5.** Thick-wall tubes of Ambrac-850 alloy to dissipate heat rapidly, prevent overheating and "flashback"; alloy has high strength for rough service, yet has sufficient machinability. **6.** Special-shape brass tube with fluting pre-formed is furnished in long lengths ready for fast, economical screw machine operation.

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EXTRUSIONS • FABRICATED METAL GOODS

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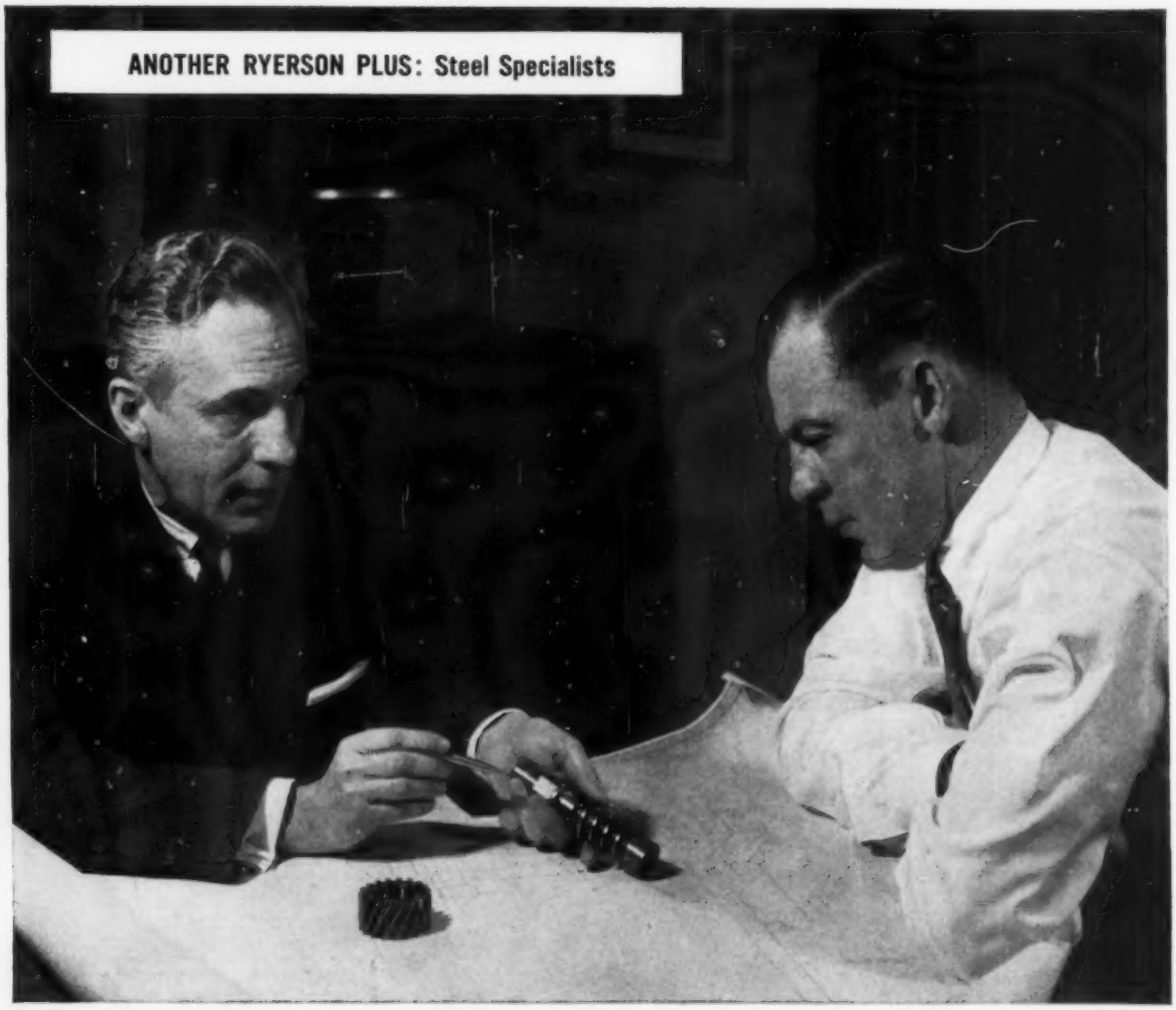
products made by
THE AMERICAN BRASS COMPANY



"Maybe there's a steel to do it better . . . ask Ryerson!"

If there is a better steel for your operation, Ryerson can tell you. A Ryerson specialist will assist you in solving the problems of steel application and fabrication, too.

Ryerson strategically located plants carry large stocks to meet virtually every steel need. That's why the Ryerson specialist will suggest only the best steel for the job. He can offer you facilities and experience to help with design problems.

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Come to Cleveland . . .

THE LAST WEEK OF THIS MONTH thousands of management executives, operating men and top technical people of the metalworking industry will come to Cleveland to attend the National Metal Congress and Exposition. This event, in its 40th year, has become sort of an official annual check-up on what's new in metals and metalworking. Six other societies are cooperating with the American Society for Metals to produce a technical program that's unequaled in engineering and scientific interest. In the Metal Exposition some 400 firms (p. 89) will show their products and services. Exhibitors will be ready to demonstrate to visitors ways to make products better and cheaper with new materials and improved processes.

In the following pages the program is arranged day by day to permit the visitor to choose the items of most interest. Fifty outstanding scientific papers have been selected by the ⊕ *Transactions* Committee for presentation (brief digests of some of these start on page 174). For the first time the Congress will feature a series of engineering conferences arranged by the Metals Engineering Program Committee. Over 40 papers dealing with the practical aspects of metalworking will be presented. These are called the William Park Woodside Panel Conferences in honor of an ⊕ founder member. Additional events include a three-day Seminar on Residual Stresses to be held the latter part of the week and a Seminar on Magnetic Properties of Metals and Alloys on the preceding week-end, Oct. 25 and 26.

As in the past, sessions of cooperating groups will contribute significantly to the value of the program. The fall meeting of the Metallurgical Society of A.I.M.E. will feature four simultaneous meetings for four days – Oct. 27 to 30. The Society for Nondestructive Testing has a full program which includes an educational clinic plus other sessions on timely topics. The Industrial Heating Equipment Association, Metal Powder Industries Federation, Metals Division of Special Libraries Association and Metal Treating Institute (a newly cooperating group) have special programs planned.

To complement the events of the month, this issue of *Metal Progress* brings outstanding features to help you do a better job with metals: A "Preview of Space Metals" (p. 96) discusses new requirements for materials and fabrication resulting from the advances being made in aircraft, missiles, and satellites; "What's New in Everyday Uses for Metals" (p. 114) emphasizes developments in alloys, design and fabrication which will help the average metalworking plant; "The Potential for Higher Temperature Carburizing" (p. 134) brings you up to date on possibilities here; and New Metallographic Techniques (p. 140) presents three good time-saving ideas.

We are in an era in which we are only beginning to witness the fantastic future in metallurgy. Why not come to the National Metal Congress and Exposition and learn first hand what better technology can mean in dollars and cents to your company! You will be well repaid for your attendance.

G. M. YOUNG, *President*
AMERICAN SOCIETY FOR METALS

40th National Metal Congress and Exposition

Cleveland, Oct. 25 through Nov. 1, 1958

American Society for Metals . . . . . **Headquarters Hotels: Statler-Hilton and Hotel Cleveland**

Seminar on Magnetic Properties of Metals and Alloys, Saturday and Sunday
Technical Sessions, Monday morning through Thursday afternoon
Metals Engineering Panel Discussions, Monday morning through Thursday afternoon (Hotel Cleveland)
Honors and Awards Luncheon, Tuesday noon.
Annual Meeting and Campbell Memorial Lecture, Wednesday morning
Annual Banquet, Thursday evening
Seminar on Residual Stresses, Thursday through Saturday (Wade Park Manor)
National Metal Exposition, Monday through Friday (Public Auditorium)

The Metallurgical Society, sponsored by the Institute of Metals Div., A.I.M.E. . . . . . **Headquarters, Carter Hotel**

Committee Meetings, Sunday through Thursday
Technical Sessions, Monday morning through Thursday morning
Annual Fall Dinner, Tuesday evening

Society for Nondestructive Testing . . . . . **Headquarters, Manger Hotel**

Educational Clinic, Monday all day
Technical Sessions, Monday through Friday
Annual Dinner, Wednesday evening

Metal Treating Institute . . . . . **(Jointly With ASM)**

Technical Session, Thursday morning

Metal Powder Industries Federation . . . . . **(Jointly With ASM)**

Technical Session, Wednesday afternoon

Industrial Heating Equipment Association . . . . . **(Jointly With ASM)**

Technical Session, Tuesday morning

Special Libraries Association, Metals Division
Headquarters, Carter Hotel

Technical Sessions and Inspection Trips, Thursday and Friday

Complete programs, grouped by days, on following pages

Saturday, October 25, 1958

9:00 A.M. Statler-Hilton — **2:00 P.M. Statler-Hilton**

Seminar on Magnetic Properties of Metals and Alloys

Introduction
By *R. M. Bozorth*, Bell Telephone Laboratories

Fundamental Questions in Magnetism
By *J. H. VanVleck*, Harvard University

Experimental Measurements of Fundamental Magnetic Properties
By *C. P. Bean*, General Electric Research Laboratories

Nuclear Resonance in Magnetic Materials
By *R. G. Shulman*, Bell Telephone Laboratories

Ferromagnetic Domain Structure
By *H. J. Williams* and *R. C. Sherwood*, Bell Telephone Laboratories

Magnetic Behavior of Thin Films
By *J. B. Goodenough*, Massachusetts Institute of Technology

Magnetic Properties of Fine Particles
By *T. O. Paine*, General Electric Instrument Dept.

8:00 P.M. Statler-Hilton

Seminar on Magnetic Properties of Metals and Alloys

Time Effects in Magnetization
By *G. W. Rathenau*, University of Amsterdam, (The Netherlands)

Sunday, October 26, 1958

9:00 A.M. Statler-Hilton — **2:00 P.M. Statler-Hilton**

Seminar on Magnetic Properties of Metals and Alloys

Magnetostriction
By *W. J. Carr, Jr.*, Westinghouse Research Laboratories

Magnetomechanical Damping
By *A. W. Cochardt*, Westinghouse Research Laboratories

Magnetic Properties and Temperature
By *B. L. Averbach*, Massachusetts Institute of Technology

Magnetic Measurements in Metallurgy
By *J. E. Goldman*, Ford Motor Co. Scientific Laboratory

Magnetic Annealing
By *C. D. Graham, Jr.*, General Electric Research Laboratories

Metallurgical Structure and Magnetic Properties
By *J. J. Becker*, General Electric Research Laboratories

Monday Morning, October 27, 1958

9:00 A.M. Statler-Hilton

Session on Diffusion and Growth

Preparation of FeO, NiO and CoO Crystals by Halide Decomposition
By *R. E. Cech* and *E. I. Alessandrini*, General Electric Research Laboratory

Spiral Growth During Vapor Deposition of Cadmium
By *W. I. Pollock*, E. I. du Pont de Nemours & Co., and *R. F. Mehl*, Carnegie Institute of Technology

Solid State Diffusion and the Motion of Phase Boundaries
By *D. D. Van Horn*, General Electric Co.

Diffusion Layer Formation in the Ternary System Aluminum-Magnesium-Zinc
By *J. B. Clark*, Dow Chemical Co. and *F. N. Rhines*, Carnegie Institute of Technology

Growth Conditions for Equiaxed Crystals in Aluminum-Magnesium Alloys
By *T. S. Plaskett* and *W. C. Winegard*, University of Toronto

9:00 A.M. Statler-Hilton

Session on Precipitation

Unique Deformation and Aging Characteristics of Certain Magnesium-Base Alloys
By *S. L. Couling, J. F. Pashak* and *L. Sturkey*, Dow Chemical Co.

The Phenomenon of "Negative Creep" in Alloys
By *R. W. Fountain* and *M. Korchynsky*, Electro Metallurgical Co.

Aging Characteristics of "Hastelloy B"
By *R. E. Clausing, P. Patriarca* and *W. D. Manly*, Oak Ridge National Laboratory

The Response of an Iron-Base Alloy, Hardened with Titanium, to Various Aging Times and Temperatures
By *T. W. Eichelberger*, Westinghouse Research Laboratories

9:00 A.M. Hotel Cleveland

First Panel Conference on Fabrication of Molybdenum

The Production of Quality Molybdenum Mill Products
By *W. L. Bruckart*, Universal Cyclops Steel Corp.

Molybdenum as a Structural Alloy
By *J. J. Harwood*, Office of Naval Research

Forming Molybdenum Sheet
By *D. C. Goldberg*, Westinghouse Electric Corp., Aviation Gas Turbine Division

9:00 A.M. Carter Hotel

Session on General Metallurgy

Freezing of Liquid Metal in a Mold
By *G. Horvay* and *J. G. Henzel*, General Electric Co.

Gas Desorption of Nickel Powders
By *J. F. Watson*, Convair Research Laboratories, and *M. J. Sinnott*, University of Michigan

Hydrogen in Cold Worked Iron-Carbon Alloys and the Mechanism of Hydrogen Embrittlement
By *M. L. Hill* and *E. W. Johnson*, Westinghouse Electric Corp.

Aging of Hydrogen Charged Steel
By *H. C. Rogers*, General Electric Co.

Fatigue in Single Crystals of Copper
By *M. L. Ebner* and *W. A. Backofen*, Massachusetts Institute of Technology

Hardening Characteristics of Polycrystalline Copper Under Fatigue Loading
By *M. L. Ebner* and *W. A. Backofen*, Massachusetts Institute of Technology

Reduction of Nickel Oxide
By *R. E. Cech*, General Electric Co.

Nucleation of Whiskers Formed by Reduction of Nickel Bromide
By *R. E. Cech*, General Electric Co.

9:00 A.M. Carter Hotel

Symposium on Point Imperfections

Irradiation Damage and Point Imperfections
By *J. W. Corbett*, General Electric Co.

Internal Friction and Point Imperfections
By *C. A. Wert*, University of Illinois

Thermal Treatment and Point Imperfections
By *A. S. Nowick*, Columbia University

9:00 A.M. Carter Hotel

Session on Oxidation and Mechanical Properties

Oxide Particle Dispersions in Internally Oxidized Copper-Aluminum Alloys
By *D. L. Wood*, General Electric Co.

Mechanical Properties of Internally Oxidized Copper-Aluminum Alloys
By *D. L. Wood*, General Electric Co.

Recrystallization of Internally Oxidized Copper-Aluminum Alloys
By *D. L. Wood*, General Electric Co.

Strengthening of Copper Alloys by Internal Oxidation
By *M. S. Ali* and *V. A. Phillips*, General Electric Co.

Effect of Oxygen on the Tensile Properties of Titanium
By *C. Feng, C. Elbaum* and *W. C. Winegard*, University of Toronto

Role of Oxide Plasticity in the Oxidation Mechanism of Pure Copper
By *J. A. Sartell, R. J. Stokes, S. H. Bendel, T. L. Johnston* and *C. H. Li*, Minneapolis-Honeywell Regulator Co.

Initial Oxidation Rate of Nickel and Effect of the Curie Temperature
By *H. Uhlig, J. Pickett* and *J. MacNairn*, Massachusetts Institute of Technology

9:00 A.M. Carter Hotel

Symposium on Research on Semiconductors

The Industrial Impact of Transistors
By *J. A. Morton*, Bell Telephone Laboratories

Review of Armed Services Activities
By *W. R. Cherry*, Evans Signal Laboratory; *R. Cornelissen*, Air Force Cambridge Research Center; and *P. H. Egli*, Naval Research Laboratory

9:00 A.M. Manger Hotel

First Session, Educational Clinic

Orientation and Statement of Scope
By *Douglas Ballard, Sandia Corp.*

Source of Defects to be Located
By *Carl E. Betz*, Magnaflux Corp.

Radiography With X-Rays
By *Wm. D. Kiehle*, Eastman Kodak Co.

Nucleonic Gaging
By *J. E. Reider*, Industrial Nucleonics Corp.

Radiography With Isotopes
By *Dana E. Elliott*, Los Alamos Scientific Laboratory

Fluoroscopy
By *Walter Hampe*, Westinghouse Electric Corp.

Penetrant Inspection
By *Robert C. Eichen*, Magnaflux Corp.

9:30 A.M. Manger Hotel

Session on Instruments and Techniques

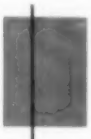
How Management Views Nondestructive Testing
By *Harvey Christen*, Lockheed Aircraft Corp.

Electrode Potential Testing
By *P. D. Edwards*, Los Alamos Scientific Laboratory

New Low-Energy Photon Sources
By *Farno L. Green* and *Willard D. Cheek* General Motors Research Staff

Improving Reliability of Electromagnetic Tests
By *Richard Hochschild*, Metrol Inc.

Monday Noon



12:00 M. Public Auditorium

40th Annual Metal Exposition Opens

Monday Afternoon, October 27, 1958

2:00 P.M. Statler-Hilton

Session on High-Temperature Metals

An X-Ray Metallographic Study of Arc-Cast Tungsten
By *S. Leber*, General Electric Co.

Temperature and Stress Dependence of the Atmosphere Effect on a Nickel-Chromium Alloy
By *P. Shahinian* and *M. R. Achter*, U. S. Naval Research Laboratory

Studies of the Oxidation and Contamination Resistance of Binary Columbium Alloys
By *C. T. Sims*, *W. D. Klopp* and *R. I. Jaffee*, Battelle Memorial Institute

High-Temperature Oxidation and Contamination of Columbium
By *W. D. Klopp*, *C. T. Sims* and *R. I. Jaffee*, Battelle Memorial Institute

2:00 P.M. Hotel Cleveland

Second Panel Conference on Fabrication of Molybdenum

Fusion Welding of Molybdenum
By *D. C. Martin*, Battelle Memorial Institute

Brazing Molybdenum
By *G. S. Hoppin III*, Aircraft Gas Turbine Div., General Electric Co.

Machining of Molybdenum
By *W. A. Taebel* and *J. Gelok*, Lamp Div., Westinghouse Electric Corp.

Protective Coating Systems for Molybdenum
By *R. I. Jaffee*, Battelle Memorial Institute

2:00 P.M. Carter Hotel

Symposium on Effect of Ordering on Mechanical Properties

Deformation Characteristics of Superlattices
By *P. A. Flinn*, Westinghouse Electric Corp.

Effect of Ordering on the Mechanical Properties of Beta Brass
By *N. Brown* and *M. Herman*, Franklin Institute

Anneal-Hardening in Aluminum Bronze
By *R. W. Cahn*, *S. Chinowsky* and *R. G. Davies*, University of Birmingham (England)

Deformation and Annealing of the Alloy Cu_3Au
By *J. B. Cohen*, *B. Roessler* and *M. B. Bever*, Massachusetts Institute of Technology

Effect of Ordering on the Plastic Behavior of an Iron-Aluminum Alloy
By *F. X. Kayser*, Ford Motor Co.

Ordering and Creep Properties of Iron-Aluminum Alloys
By *A. Lawley*, University of Pennsylvania and *R. W. Cahn*, University of Birmingham (England)

2:00 P.M. Carter Hotel

Session on Annealing

Effect of Atmosphere on Secondary Recrystallization in High-Purity Silicon-Iron
By *J. L. Walter* and *C. G. Dunn*, General Electric Co.

Secondary Recrystallization of a Cube-Oriented Nucleus
By *C. G. Dunn* and *J. L. Walter*, General Electric Co.

Secondary Recrystallization in Silicon-Iron
By *J. E. May* and *D. Turnbull*, General Electric Co.

Tertiary Recrystallization in Silicon-Iron
By *J. L. Walter* and *C. G. Dunn*, General Electric Co.

Temperature Dependence of Preferred Orientation in Rolled Tungsten
By *J. W. Pugh*, General Electric Co.

Determination of Preferred Orientation
By *C. G. Dunn*, General Electric Co.

Perfection of Aluminum and Copper Crystals Grown in the Solid State
By *M. N. Parthasarathi* and *P. A. Beck*, University of Illinois

Annealing of Point Defects in Cold-Worked Tungsten and the Influence of Impurities on the Kinetics
By *L. A. Neimark*, Argonne National Laboratory, and *R. A. Swalin*, University of Minnesota

Temperature Dependence of Grain Boundary Migration in High-Purity Lead Containing Small Additions of Tin
By *K. T. Aust* and *J. W. Rutter*, General Electric Co.

2:00 P.M. Carter Hotel

Session on Equilibrium and Microstructure

Zirconium and Hafnium Phases Isostructural With Ti_2Ni
By *M. V. Nevitt* and *L. H. Schwartz*, Argonne National Laboratory

The Ternary System Zirconium-Silicon-Boron
By *Erwin Parthe* and *J. T. Norton*, Massachusetts Institute of Technology

Solid-Liquid Phase Equilibrium in the Bi_2Te_3-Bi_2Se_3 Pseudo-Binary System
By *J. P. McHugh* and *W. A. Tiller*, Westinghouse Electric Corp.

Use of Controlled Solidification in Equilibrium Diagram Studies
By *W. A. Tiller*, Westinghouse Electric Corp.

CsCl-Type Equi-Atomic Phases in Binary Alloys of Transition Elements
By *A. E. Dwight*, Argonne National Laboratory

Effect of Chromium on the Stability of Cementite
By *George Sandoz* and *B. F. Brown*, U. S. Naval Research Laboratory

2:00 P.M. Carter Hotel

First Session on Deformation

Anomalous Effect of Hydrogen on the Mechanical Properties of 92-8 Ti-Mn and 92-4-4 Ti-Al-Mn Alloys
By *A. H. Fleitman*, Crane Co.

Effect of Complexing on Mechanical Properties of 91-6-3 Ti-Al-Mo Alloy
By *F. A. Crossley*, Armour Research Foundation, and *W. F. Carew*, Joliet Metallurgical Laboratories, Inc.

A Decision Technique for Evaluating the Effect of Melting and Casting Environment on Stress-Rupture Properties
By *J. T. Brown*, Westinghouse Electric Corp.

Ductility of Polycrystalline Ceramics
By *C. E. May, H. H. Grimes* and *R. A. Lad*, National Advisory Committee for Aeronautics

Short-Time Creep of Some Graphites at 3000 to 5300° F.
By *H. E. Martens, L. D. Jaffe* and *D. D. Button*, California Institute of Technology

Effect of Surface Condition on the Initiation of Plastic Flow in Magnesium Oxide
By *R. J. Stokes, T. L. Johnston* and *C. H. Li*, Minneapolis-Honeywell Regulator Co.

Three Dimensional Ductility and Crack Propagation of Preferentially Oriented Beryllium Sheet
By *F. M. Yans* and *A. R. Kaufmann*, Nuclear Metals, Inc.

Creep of a Dispersion-Hardened Aluminum Alloy
By *G. S. Ansell* and *J. Weertman*, United States Naval Research Laboratory

1:45 P.M. Manger Hotel

Second Session, Educational Clinic

Eddy Currents
By *Richard Hochschild*, Metrol, Inc.

Magnetic Particles
By *W. E. Thomas*, Magnaflux Corp.

Ultrasonics (Reflection and Contact Techniques)
By *John C. Smack*, Curtiss-Wright Corp.

Ultrasonics (Immersion Techniques)
By *Wm. C. Hitt*, Douglas Aircraft Corp.

Ultrasonics (Resonance Techniques)
By *K. P. Hayes*, Branson Instruments Inc.

Educational and Training Problems
By *Robert C. McMaster*, Ohio State University

2:00 P.M. Manger Hotel

Session on Testing of Honeycombs and Sandwiches

Evaluation of Brazed Honeycomb Sandwich Structures
By *Frank J. Filippi*, Solar Aircraft Co.

Nondestructive Testing of Nonmetallics
By *Carl E. Betz*, Magnaflux Corp.

Measuring Cladding Thickness by Eddy Currents
By *R. A. Nance* and *J. W. Allen*, Oak Ridge National Laboratory

Immersed Ultrasonic Inspection of Plates
By *R. W. McClung*, Oak Ridge National Laboratory

Testing of Bonded and Brazed Aircraft Structures
By *Thomas G. Bogle*, Temco Aircarft Corp.

Evaluation of Bond Quality in Honeycomb by Ultrasonic Surface Wave Techniques
By *E. T. Hughes* and *E. Burnstein*, Westinghouse Electric Corp.

Tuesday Morning, October 28, 1958

9:00 A.M. Statler-Hilton

First Session on Steel

Mechanical Properties of Fe-Al-Si Alloys at Room and Elevated Temperatures
By *D. J. Schmatz* and *V. F. Zackay*, Ford Motor Co.

Multiplying Factors for the Calculation of Hardenability of Hyper-Eutectoid Steels Hardened from 1700° F.
By *C. F. Jatczak* and *D. J. Girardi*, Timken Roller Bearing Co.

Recrystallization, Structure, and Hardness of Low-Carbon Steels Containing up to 1% Copper
By *R. L. Rickett* and *W. C. Leslie*, United States Steel Corp. Research Center

Effect of Copper on the Heat Treating Characteristics of Medium-Carbon Steel
By *R. A. Grange* and *J. J. Harrington*, U. S. Steel Corp., and *V. E. Lambert*, Lamp Div., Westinghouse Electric Corp.

9:00 A.M. Statler-Hilton

Session on Mechanical Properties

The Relationship Between Weld Cracking and Alloy Constitution in Some Binary and Ternary Magnesium Alloys
By *C. L. Kobrin* and *R. A. Dodd*, University of Pennsylvania

Stress Effects of Abrasive Tumbling
By *H. R. Letner*, General Electric Co.

Thermal and Mechanical Fatigue of Nickel and Titanium
By *Harry Majors, Jr.*, Seattle University

A Compilation and Interpretation of Cyclic Strain Fatigue Tests on Metals
By *J. F. Tavernelli* and *L. F. Coffin, Jr.*, General Electric Research Laboratory

9:00 A.M. Hotel Cleveland

First Panel Conference on Quenching of Steels

The How and Why of Quenching
By *C. A. Siebert*, University of Michigan

Quenching—A Thermal Process
By *V. Paschkis*, Columbia University

Evaluation of Quenching Media
By *G. H. Robinson* and *H. J. Gilliland*, General Motors Research Staff

9:00 A.M. Hotel Cleveland

Panel Conference on Precision Mechanical Springs

Types of Springs in General Use
By *John B. Beckwith*, Wallace Barnes Div., Associated Spring Corp.

Role of Stress in Spring Performance
By *A. M. Wahl*, Westinghouse Electric Research Laboratories

Behavior of Springs at Elevated Temperatures
By *W. R. Johnson*, Associated Spring Corp.

Spring Materials
By *Lem Kulze*, Gibson Division

9:00 A.M. Carter Hotel

Symposium on Physical Chemistry of Halide Systems

Factors Affecting the Rate of Deposition of Metals in Thermal Dissociation Processes
By *G. H. Kesler*, Battelle Memorial Institute

Iodide Columbium
By *R. F. Rolsten*, E. I. du Pont de Nemours and Co., Inc.

Use of Heat and Mass Transfer Model Studies to Evaluate Rates of Deposition of Metals in Complex Systems
By *J. H. Oxley* and *G. H. Kesler*, Battelle Memorial Institute, and *C. E. Dryden*, Ohio State University

9:00 A.M. Carter Hotel

Symposium on Effects of Small Dimension

Properties of Whiskers
By *N. Cabrera*, University of Virginia

Mechanical Properties of Thin Films
By *J. W. Beams*, University of Virginia

Magnetic Properties of Whiskers, Thin Films and Small Particles
By *C. P. Bean*, General Electric Co.

9:00 A.M. Carter Hotel

First Session on Steelmaking in the Soviet Union

Raw Materials
By *J. B. Austin*, United States Steel Corp.

Blast Furnaces and Coking
By *J. H. Strassburger*, National Steel Corp.

Open Hearths
By *M. F. Yarotsky*, United States Steel Corp.

Electric Furnaces
By *K. C. McCutcheon*, Consulting Engineer

9:00 A.M. Carter Hotel

First Meeting on Titanium Metal

Panel Discussion on Price, Quality and New Process Prospects for Titanium Sponge, Ingot, and Billet
By *Graham Brown*, Mallory-Sharon Metals Corp., *D. H. Baker, Jr.*, U. S. Bureau of Mines; *G. A. Moudry*, Harvey Aluminum Co., *W. E. Lusby, Jr.*, E. I. du Pont de Nemours and Co., Inc., and summary by *H. H. Kellogg*, Columbia University

Price Trends and Market Analysis of Titanium Products
By *R. L. Vroome*, Electro Metallurgical Co.

Panel Discussion on Current and New Uses of Titanium in Missiles, Aircraft, and Aircraft Power Plants
By *W. H. Sharp*, Pratt and Whitney Aircraft Division of United Aircraft Corp., *A. Hurlich*, Convair Astronautics, and *L. J. Hull*, Ryan Aeronautics Co.

9:00 A.M. Statler-Hilton (Jointly with ASM)

Engineering and Technological Development in Induction Heating Processes

Engineering and Economic Elements in the Choice of Induction Heating Equipment
By *C. F. Olmstead*, Lee Wilson Engineering Co.

Vacuum as a Furnace Atmosphere
By *L. W. Johnson*, General Electric Co.

Austempering, Martempering and Isothermal Heat Treating in Basic Industry
By *A. F. Holden*, A. F. Holden Co.

Improvements in Induction Heating
By *W. E. Benninghoff*, Tocco Div., Ohio Crankshaft Co.

9:00 A.M. Manger Hotel

Session on Evaluation of Welds

Ultrasonic Inspection of Welds
By *John E. Bobbin*, Sperry Products, Inc.

Inspection of Ship Welds by Radio-Isotopes
By *Daniel Polansky, E. L. Criscuolo* and *D. P. Case*, U. S. Naval Ordnance Laboratory

Testing in a Small Manufacturing Plant
By *A. G. Barkow*, Marquette University, and *S. J. Boehringer*, Boehringer Engineering Products, Inc.

Radiographic Inspection of Welded Turbine Wheels for Jet Starters
By *A. R. Potenski*, Bendix Aviation Corp.

Weld Evaluation by Magnetic Particles and Liquid Penetrants
By *Paul Maertz*, A. O. Smith Corp.

Radiography of Welds in Highway Bridges
By *J. L. Beaton* and *Paul G. Jonas*, California Div. of Highways

Tuesday Noon

12:00 M. Statler-Hilton

Annual Awards Luncheon

Tuesday Afternoon, October 28, 1958

2:00 P.M. Statler Hilton

Second Session on Steel

The Mechanism of the Allotropic Transformation in High-Purity Iron
By *E. Eichen* and *J. W. Spretnak*, Ohio State University

Mechanical Properties of Deformed Metastable Austenitic Ultra-High-Strength Steel
By *D. J. Schmatz* and *V. F. Zackay*, Ford Motor Co.

Magnetic Analysis of Phase Changes Produced in Tempering a High-Carbon Steel
By *M. Mentser*, U. S. Bureau of Mines

Austenite Transformation and Incubation in an Alloy Steel of Eutectoid Carbon Content
By *R. A. Grange, P. T. Kilhefner, Jr.*, and *T. P. Bittner*, United States Steel Corp.

A Simplified Procedure for Calculating Peak Position in X-Ray Residual Stress Measurements on Hardened Steel
By *D. P. Koistinen* and *R. E. Marburger*, General Motors Corp.

2:00 P.M. Hotel Cleveland

Second Panel Conference on Quenching of Steels

Hot Quenching
By *William Hiatt*, International Harvestor Co.

Basis of Selection of Quenching Media
By *R. H. Lauderdale*, Northern Ordnance, Inc.

Automatic Quenching Equipment
By *O. E. Cullen*, Surface Combustion Corp.

2:00 P.M. Carter Hotel

Second Session on Deformation

Slip in Aluminum-Silver Single Crystals
By *A. Kelly, A. Lassila*, and *S. Sato*, Northwestern University

Experimental Observations of Some Dislocation Sources
By *J. J. Gilman*, General Electric Co.

Photographic Evidence of Frank-Read Dislocation Sources in Zinc
By *V. Damiano* and *M. Herman*, Franklin Institute

Flow Stress of Iron and its Dependence on Impurities
By *G. C. Schoeck*, Westinghouse Electric Corp., and *A. Seeger*, Max Plank Institut fur Metallforschung, (Germany)

Dislocation Behavior During Initial Creep of Silver
By *M. S. Abrahams* and *N. S. Machlin*, Columbia University

Effect of Changes in Slip Direction on the Creep of Magnesium Crystals
By *Hans Conrad*, Westinghouse Electric Corp.

Activation Energies for Creep of Single Aluminum Crystals Favorably Oriented for Cubic Slip
By *Y. A. Rocher, L. A. Shepard* and *J. E. Dorn*, University of California

Factors Affecting Ductility and Strength of NaCl Single Crystals Tested in Flexure
By *C. A. Stearns, A. E. Pack* and *R. A. Lad*, National Advisory Committee for Aeronautics

2:00 P.M. Carter Hotel

Session on Applications of Phase Rule in Extractive Metallurgy

Graphical Representation of Heterogeneous Ternary Equilibria
By *J. H. Downing*, Electro Metallurgical Co.

Heterogeneous Equilibria in Multi-Component Systems
By *L. S. Darken*, United States Steel Corp.

Recent Studies of Geological Materials at High Pressures and Temperatures
By *J. F. Schairer*, Carnegie Institute of Washington

Representation and Interpretation of Phase Equilibria in Oxide Systems Involving Changes in Oxidation States
By *A. Muan*, Pennsylvania State University

Approximate Ternary Phase Diagram Silicon-Oxygen-Carbon
By *W. A. Krivsky*, Electro Metallurgical Co.

Quaternary Systems
By *R. Schuhmann, Jr.*, Purdue University

2:00 P.M. Carter Hotel

Second Session on Steelmaking in the Soviet Union

Rolling Mills
By *F. S. Eckhardt*, Bethlehem Steel Co.

Direction of Steelmaking Research and Development
By *J. F. Elliott*, Massachusetts Institute of Technology

Vacuum Techniques
By *A. M. Aksoy*, Crucible Steel Co. of America

Alloy Steels
By *Gunther Mohling*, Allegheny Ludlum Steel Corp.

2:00 P.M. Carter Hotel

Second Meeting on Titanium Metal

Panel Discussion on the Sheet Rolling Program
By *C. W. Alesch*, Convair; *T. H. Gray*, Boeing Airplane Co.; and *W. W. Wood*, Chance Vought Aircraft, Inc.

Sheet Rolling Program, Phases I and II
By *N. E. Promisel*, U. S. Navy Bureau of Aeronautics

Panel Discussion on New Alloys of Titanium
By *Harold Margolin*, New York University; *S. A. Herres*, Titanium Metals Corp. of America; *W. L. Finlay*, Crucible Steel Co. of America and *T. E. Perry*, Republic Steel Corp.; Summary by *R. I. Jaffee*, Battelle Memorial Institute

Sheet Rolling Program, Phase III
By *George Sachs*, University of Syracuse

2:00 P.M. Manger Hotel

Session on Radiography

New Techniques for Non-Photographic Observation
By *H. E. Haynes*, Radio Corp. of America

Device for Intensifying the Fluoroscopic Image
By *E. L. Criscuolo* and *C. Dyer*, U. S. Naval Ordnance Laboratory

An Electronic, High-Resolution, X-Ray Image
By *J. W. Allen* and *R. W. McClung*, Oak Ridge National Laboratory

Continuous Display of High-Energy X-Ray Images
By *John S. Pruitt*, National Bureau of Standards

Comparison of 1 MEV Resotron and Van de Graaff Units
By *D. E. Elliott*, Los Alamos Scientific Laboratory and *C. M. Knowles*, Oak Ridge National Laboratory

Status Report on Ionography
By *R. A. Youshaw* and *J. A. Holloway*, U. S. Naval Ordnance Laboratory

Tuesday Evening

6:30 P.M. Carter Hotel

A.I.M.E. Cocktail Party and Dinner

Wednesday Morning, October 29, 1958

9:00 A.M. Statler-Hilton

A.S.M. Annual Meeting and Campbell Memorial Lecture

9:00 A.M. Hotel Cleveland

First Panel Conference on Modern Machining Methods

New Cutting Tool Materials
By *R. T. Hook*, The Warner & Swasey Co.

Constant Speed Machining
By *M. C. Shaw*, Massachusetts Institute of Technology

Quick Change, Pre-Set Tooling
By *Anthony S. Rogers*, Wesson Co.

9:00 A.M. Carter Hotel

Session on Oxidation Protection and Fabrication of Refractory Metals

Nucleation and Growth of Chromium on Molybdenum in Liquid Metal Solutions
By *J. Wulff* and *S. T. Wlodek*, Massachusetts Institute of Technology

Metallic Coatings for Molybdenum
By *G. D. Oxx*, General Electric Co.

Arc Melting and Fabrication of Tungsten
By *S. J. Noesen, J. R. Hughes, C. L. Kolbe,* and *R. C. Leech*, General Electric Co.

Orientation of Large Grains in Annealed Tungsten Wire
By *A. J. Opinsky* and *J. L. Drehotsky*, Sylvania Electric Products, Inc.

Arc Melting, Fabrication, and Annealing of Tantalum to Produce Foil
By *S. J. Noesen, M. A. Cocca* and *R. C. Leech*, General Electric Co.

9:00 A.M. Carter Hotel

Session on Ceramic Base Elements

Fabrication of Ceramic Fuel Elements by Swaging
By *D. R. Stenquist* and *R. J. Anovetti*, General Electric Co.

Pressure Bonding of Zircaloy-Clad, Flat-Plate Fuel Elements of Uranium Dioxide
By *S. J. Paprocki, E. S. Hodge* and *D. C. Carmichael*, Battelle Memorial Institute

Fabrication of Aluminum-Clad Plate-Type Elements Containing UO_2 as the Fuel
By *B. Megeff* and *J. L. Zambrow*, Sylvania-Corning Nuclear Corp.

Fuel Components of Stainless Steel and Uranium Dioxide for the Army Package Power Reactor
By *J. E. Cunningham* and *R. J. Beaver*, Oak Ridge National Laboratory

Preparation of Zirconium-Base Dispersion Fuels
By *A. P. Beard* and *R. H. Honeyman*, General Electric Co.

Fuel Elements of Uranium and Zirconium Hydride for Triga Reactors
By *W. P. Wallace, M. T. Simnad* and *B. Turovlin*, General Atomics Div. of General Dynamics Corp.

9:00 A.M. Carter Hotel

Session on High-Purity Metals

Growth of Molybdenum, Tungsten and Columbium Crystals by Floating-Zone Melting in Vacuum
By *E. Buehler*, Bell Telephone Laboratories, Inc.

Determination of the Limiting Segregation of Gallium in Zone-Refined Germanium
By *L. W. Davies*, Commonwealth of Australia

Zone Melting of Magnesium
By *A. S. Yue*, Dow Chemical Co.

9:00 A.M. Carter Hotel

Session on Precipitation and Segregation

Acoustical Study of G. P. Zone Formation After Reversion in 80-20 Al-Ag Alloy
By *Herbert Herman* and *M. E. Fine*, Northwestern University

Critical Particle Size for Precipitation Hardening
By *J. D. Livingston*, General Electric Co.

Precipitation of Silicon From a Supersaturated Solid Solution in Aluminum
By *H. S. Rosenbaum*, General Electric Co.

Correlation Between Sub-Boundaries and Impurities in Super-Purity Aluminum
By *D. Altenpohl*, Aluminum Foils, Inc.

9:00 A.M. Manger Hotel

Session on Measurement and Evaluation

Industrial Applications of Radio-Isotopes
By *Stelios Regas*, Radiation Counter Laboratories, Inc.

Advances in Gaging With Radio-Isotopes
By *Oscar M. Bizzell*, U. S. Atomic Energy Commission

Evaluation of Nondestructive Tests on Cermet Turbine Blades
By *A. G. Holms* and *A. J. Repko*, Lewis Flight Propulsion Laboratory

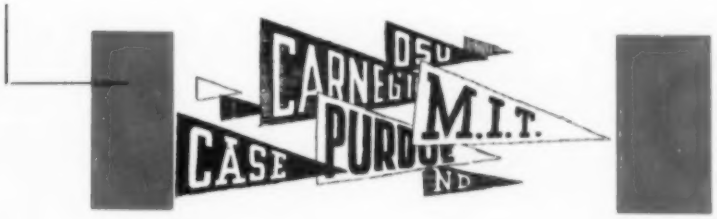
Radiographic Inspection of Inaccessible Internal Dimensions
By *Harlan Howard*, Dalmo Victor Co.

Early Detection of Fatigue in Aluminum Alloys by Ultrasonics
By *Karl Sittell*, The Franklin Institute

Fatigue Properties of Ultrasonically Tested Plates and Forgings (Aluminum Alloy)
By *J. L. Waisman*, Tatnall Measuring Systems, *L. L. Soffa*, Northrup Aircraft, Inc., *P. W. Kloeris* and *C. S. Yen*, Douglas Aircraft Co.

Wednesday Noon

University Alumni Luncheons



Wednesday Afternoon, October 29, 1958

2:00 P.M. Statler-Hilton

Session on Brittle Fracture

Cleavage Step Formation in Brittle Fracture Propagation
By *J. M. Berry*, General Electric Research Laboratory

Effect of Grain Size and Carbon Content on Yield Delay of Mild Steel
By *J. M. Krafft* and *A. M. Sullivan*, U.S. Naval Research Laboratory

Some Low-Temperature Observations on 1020 Steel
By *F. S. Deronja* and *M. Gensamer*, Columbia University

Low-Temperature Embrittlement of Austenitic Cr-Mn-N-Fe Alloys
By *F. W. Schaller*, Case Institute of Technology and *V. F. Zackay*, Ford Motor Co. Scientific Laboratory

The Transition Temperature in a Notched-Bar Impact Test
By *J. A. Hendrickson*, California Research Corp., *D. S. Wood* and *D. S. Clark*, California Institute of Technology

2:00 P.M. Hotel Cleveland

Second Panel Conference on Modern Machining Methods

Trends in High-Speed Equipment
By *M. S. Curtis*, The Warner & Swasey Co.

Chipless Machining
By *R. D. Halverstadt* and *R. Cogan*, Aircraft Gas Turbine Div., General Electric Co.

Machining High-Strength Materials
By *Roger W. Runyan*, Menasco Mfg. Co.

2:00 P.M. Hotel Cleveland

Panel Conference on Production of High-Quality Castings

In Aircraft and Missiles
By *Mrs. Rebecca H. Sparling*, Pomona Div., Convair

In the Petroleum Refining Industry
By *N. J. Rees* and *R. W. Manuel*, Socony Mobil Oil Co., Inc.

By the Railroads
By *W. R. Elsey*, Pennsylvania Railroad Co.

In Machine Tools
By *Herbert Whitney*, Kearney & Trecker Corp.

2:00 P.M. Statler-Hilton

Session on Uranium

Transformation Kinetics of Beta Plutonium
By *R. D. Nelson*, Hanford Atomic Products Operation

Transformation Characteristics of Dilute Ternary Alloys of Uranium
By *D. J. Murphy*, University of Arizona

The Mechanical Properties and Heat Treatment Response of Zirconium-Uranium Alloys
By *W. Chubb* and *F. A. Rough*, Battelle Memorial Institute

Preparation of Uranium and Uranium Alloy Powder Metal Compacts
By *Herbert S. Kalish*, Sylvania-Corning Nuclear Corp.

Properties of Cast and Heated 2% Molybdenum-Uranium
By *E. G. Zukas*, Los Alamos Scientific Laboratory

2:00 P.M. Carter Hotel

Session on Nuclear Fuels and Jacketing

Silicon-Modified Uranium-Aluminum Alloys for Foreign Reactors
By *W. C. Thurber* and *R. J. Beaver*, Oak Ridge National Laboratory

Fabrication of Fuel Rods of U-Mo Mixture, Clad With Zircaloy-2
By *J. G. Goodwin, R. W. Tombaugh, E. L. Richards* and *F. R. Lorenz*, Westinghouse Electric Corp.

Manufacture of EBR-I Mark III Fuel and Blanket Elements
By *R. A. Noland, N. J. Carson, C. C. Stone, R. E. Macherey* and *F. D. McCraig*, Argonne National Laboratory

Fabrication of Iron-Aluminum-Chromium Fuel Plates
By *F. G. Tate, J. Neri* and *Blake King*, The Martin Co.

Bonding of Aluminum With Elemental Silicon
By *R. A. Noland* and *D. E. Walker*, Argonne National Laboratory

Alternate Bonding Techniques for Fuel Element Components
By *F. L. Orrell* and *H. R. Hoge*, Westinghouse Electric Corp.

Fuel Element Closures
By *J. E. Minor* and *S. H. Bush*, General Electric Co.

2:00 P.M. Carter Hotel

Session on Columbium and Its Alloys

Oxidation of a Columbium-Zirconium Alloy
By *G. M. Gordon, R. Speiser* and *J. W. Spretnak*, Ohio State University

Some Physical and Mechanical Properties of Columbium and Its Alloys
By *R. T. Begley* and *L. L. France*, Westinghouse Electric Corp.

Some Effects of Alloying on the Strength of Columbium at Elevated Temperatures
By *G. D. Gemmell*, E. I. du Pont de Nemours & Co., Inc.

Properties of Some Columbium Alloys
By *R. G. Frank*, General Electric Co.

Properties of the Ternary Columbium Alloy With 10% Ti and 10% Mo.
By *A. H. Grobe*, Thompson Products, Inc. and *H. B. Hix*, E. I. du Pont de Nemours & Co., Inc.

Hot Hardness of Some Columbium Alloys
By *A. L. Eiss, L. Sama* and *H. P. Kling*, Sylvania-Corning Nuclear Corp.

Mechanical Properties and Oxidation Resistance of Columbium Alloys
By *F. R. Schwartzberg, D. N. Williams* and *R. I. Jaffee*, Battelle Memorial Institute

2:00 P.M. Carter Hotel

Symposium on Electrical and Magnetic Metals

Magnetic Methods in Metallurgy
By *Anthony Arrott*, Ford Motor Co.

Physical Metallurgy of Magnetic Materials
By *J. J. Becker*, General Electric Co.

Applications of Magnetic Materials
By *M. F. Littmann*, Armco Steel Corp.

The Heusler Alloys
By *F. A. Hames*, Queens University (Ontario)

Wednesday afternoon continued on next page

2:00 P.M. Carter Hotel

Session on Transformations

Correlation of Transformation Behavior With Mechanical Properties of Several Titanium-Base Alloys
By *A. J. Griest, J. R. Doig* and *P. D. Frost*, Battelle Memorial Institute

Lattice Stability of Titanium and Zirconium
By *Larry Kaufman*, Manufacturing Laboratories, Inc.

Relation Between Beta Grain Size and Ductility of High-Strength Alpha-Beta Titanium Alloys
By *A. J. Griest, A. P. Young* and *P. D. Frost*, Battelle Memorial Institute

Effects of Aluminum on Morphology and Kinetics of Alpha Formation in a 90-10 Ti-Mo Alloy
By *H. I. Aaronson*, Ford Motor Co., *W. B. Triplett*, Carnegie Institute of Technology, and *G. M. Andes*, E. I. du Pont de Nemours & Co., Inc.

Effects of Composition on Transformation in Titanium-Chromium Alloys
By *H. I. Aaronson*, Ford Motor Co., *W. B. Triplett*, Carnegie Institute of Technology, and *G. M. Andes*, E. I. du Pont de Nemours & Co., Inc.

The Alpha-to-Beta Transformation in Zircaloy-2
By *Josef Intrater*, Materials Research Corp.

Orientation of Single Martensite Plates in Austenite
By *Henry M. Otte*, Research Institute for Advanced Study

Order-Disorder Transformations in Iron-Aluminum Alloys
By *H. J. McQueen* and *G. C. Kuczynski*, University of Notre Dame

Measurement of Grain Contiguity in Two-Phase Alloys
By *J. Gurland*, Brown University

2:00 P.M. Manger Hotel

Annual Meeting and Honor Lecture

Lester Honor Lecture
By *John A. Barclay*, Brig. Gen., U.S.A., Redstone Arsenal

2:00 P.M. Hotel Cleveland

Joint Session with ASTM on Engineering Aspects of Powder Metallurgy Structural Components

Introduction
By *Kempton H. Roll*, Metal Powder Industries Federation

Tolerances
By *Robert Burgess*, Burgess-Norton Mfg. Co.

Properties
By *Harold Harrison*, Presmet Corp.

Design
By *Peter Schneider*, International Business Machines Corp.

Summation
By *George A. Roberts*, Vanadium-Alloys Steel Co.

7:30 P.M. Manger Hotel

Banquet and Awards

Presentation of Kahn, deForest, Coolidge and duPont Awards

Flight Safety and Reliability
By *Joseph D. Caldara*, Maj. Gen., U.S.A.F., Norton Air Force Base

Thursday Morning, October 30, 1958

9:00 A.M. Statler-Hilton

First Session on Titanium

The Application of Rate Process Theory to the Heat Treatment of Titanium Alloys
By *N. M. Erkun,* Crucible Steel Co. of America

The Effects of Microstructure and Heat Treatment on the Hydrogen Embrittlement of Alpha-Beta Titanium Alloys
By *D. N. Williams, F. R. Schwartzberg* and *R. I. Jaffee* Battelle Memorial Institute

The Effect of Composition on the Hydrogen Embrittlement of Alpha-Beta Titanium Alloys
By *R. I. Jaffee* and *D. N. Williams,* Battelle Memorial Institute

Hydrogen Embrittlement and Delayed Failure in Titanium Alloys
By *R. D. Daniels,* University of Oklahoma, and *R. J. Quigg* and *A. R. Troiano,* Case Institute of Technology

The Corrosion, Pyrophoricity, and Stress Corrosion Cracking of Titanium Alloys in Fuming Nitric Acid
By *John B. Rittenhouse,* California Institute of Technology

9:00 A.M. Statler-Hilton

Session on Creep

The Activation Energies for Creep of Polycrystalline Copper and Nickel
By *P. R. Landon, J. L. Lytton, L. A. Shepard* and *J. E. Dorn,* University of California

A Procedure for Application of Time-Temperature Parameters to Accelerated Creep-Rupture Testing
By *S. S. Manson, G. Succop* and *W. F. Brown Jr.,* Lewis Flight Propulsion Laboratory

Effect of Strain Rate and Temperature on the Compressive Flow Stresses of Three Titanium Alloys
By *A. J. Griest, A. M. Sabroff* and *P. D. Frost,* Battelle Memorial Institute

Temperature and Rate Dependence of Strain Hardening in the Aluminum Alloy 2024-O
By *D. S. Fields, Jr.,* Aluminum Co. of America, and *W. A. Backofen,* Massachusetts Institute of Technology

9:00 A.M. Hotel Cleveland

Panel Discussion on Materials for High Pressure

Special Materials Problems in High-Pressure Applications
By *Donald S. Nulk,* Thompson Products, Inc.

Ultra-High-Strength Pressure Vessels in the Missiles Field
By *Walter S. Tenner,* Aerojet-General Corp.

Thursday Morning, October 30, 1958

9:00 A.M. Hotel Cleveland

Panel Discussion on High-Velocity (Explosive) Forming

High-Energy-Rate Forming by Machine
By *J. B. Ottestad*, Convair, San Diego

Explosive Forming Under Water
By *E. W. Fedderson*, Convair, Fort Worth

Explosive Forming by Direct Application
By *A. H. Petersen*, Lockheed Aircraft Corp.

9:00 A.M. Carter Hotel

Symposium on Interstitials

Dislocations in Molybdenum
By *R. D. Forrest* and *D. W. Bainbridge*, Colorado School of Mines

Effect of Variations in Carbon and Oxygen Contents on the Properties of Wrought Molybdenum-Titanium Alloys
By *M. Semchyshen* and *R. Q. Barr*, Climax Molybdenum Co.

Strengthening by Carbide Dispersion in Molybdenum Alloys
By *W. H. Chang*, General Electric Co.

Effect of Deoxidation and Denitrification on the Low-Temperature Properties of Chrominum
By *H. L. Levingston* and *N. J. Grant*, Massachusetts Institute of Technology

Influence of Interstitial Content and Processing Variables on Columbium
By *A. L. Mincher* and *W. F. Sheely*, Electro Metallurgical Co.

High-Temperature Tensile Properties of Molybdenum and Tungsten
By *R. W. Hall* and *P. F. Sikora*, Lewis Flight Propulsion Laboratories

9:00 A.M. Carter Hotel

Session on Diffusion

Layer Growth During Interdiffusion in the Aluminum-Nickel System
By *L. S. Castleman* and *L. L. Seigle*, Sylvania Electric Products Inc.

Relaxation of Atoms Surrounding a Vacancy in Cubic Metals
By *L. A. Girifalco* and *V. G. Weizer*, National Advisory Committee for Aeronautics

Effect of Static Strains on Solid-State Diffusion
By *L. A. Girifalco* and *H. H. Grimes*, National Advisory Committee for Aeronautics

Effect of Plastic Flow on Self-Diffusion in Silver
By *A. F. Forestieri* and *L. A. Girifalco*, National Advisory Committee for Aeronautics

Self-Diffusion in Tin Single Crystals
By *J. D. Meakin* and *Eric Klokholm*, The Franklin Institute

Interstitial Stress Relaxation in Ternary Alloy Systems
By *D. Gupta*, University of Illinois, and *Sheldon Weinig*, Materials Research Corp.

Short Circuit Diffusion
By *G. T. Murray*, Materials Research Corp. and *E. S. Machlin*, Columbia University

Formation of Surface Pits by the Condensation of Vacancies
By *P. E. Doherty* and *R. S. Davis*, Harvard University

Ordering Internal Friction in Iron-Aluminum Alloys Induced by Stress
By *J. C. Shyne*, Ford Motor Co., and *M. J. Sinnott*, University of Michigan

9:00 A.M. Carter Hotel

Symposium on Powder Metallurgy

High-Purity Tantalum
By *R. F. Rolsten*, E. I. du Pont de Nemours & Co.

Oxidation Resistance and Fabricability of Molybdenum-Nickel Dispersion Alloys
By *E. S. Bartlett*, *D. N. Williams* and *R. I. Jaffee*, Battelle Memorial Institute

Effect of Sintering Treatment on Electropotential and Strength of Carbonyl Iron
By *Bennett Bovarnick*, Watertown Arsenal

Some Properties and Metallography of Steel-Bonded Titanium Carbide
By *Martin Epner* and *Eric Gregory*, Sintercast Corp. of America

Highlights of the Third Plansee Seminar in Reutte, Tyrol
By *Werner Leszynski*, Schwartzkopf Development Corp.

9:00 A.M. Carter Hotel

Session on Deformation and Fracture

Cause of Cleavage Fractures in Ductile Materials
By *J. Washburn, A. E. Gorum* and *E. R. Parker*, University of California

Deformation Resulting From Grain Boundary Sliding
By *Hans Brunner* and *N. J. Grant*, Massachusetts Institute of Technology

Grain-Boundary Sliding in Aluminum and Aluminum-Magnesium Alloys From 410 to 940° F.
By *Hans Brunner* and *N. J. Grant*, Massachusetts Institute of Technology

Stress Analysis of the Bausch-Type Shear Test
By *W. L. Phillips, Jr., Dana Young* and *W. D. Robertson*, Yale University

Evaluation of the AgCl-Al_2O_3 System for Strengthening of Solids by Fine Particles
By *T. L. Johnston, R. J. Stokes* and *C. H. Li*, Minneapolis-Honeywell Regulator Co.

Effect of Liquid Metal Environments on the Fracture Strength of Solid Copper
By *D. A. Kraai, D. V. Ragone* and *E. E. Hucke*, University of Michigan

Temperature Dependence of the Tensile Properties of Face-Centered Cubic Metals
By *R. P. Carreker, Jr.*, General Electric Co.

Initiation of Tensile Fracture in Ductile Metals
By *H. C. Rogers*, General Electric Co.

9:30 A.M. Hotel Cleveland

Joint Session with ⬢ on Heat Treating

Limiting Distortion of High-Strength Steels With Simple Tempering Fixtures
By *Fred Heinzelman, Jr.*, Fred Heinzelman & Sons

Heat Treatment in a Vacuum
By *R. C. Gross*, Kinetics Corp.

Expected Variation in Hardenability of A.I.S.I. 4142 Steel
By *Charles F. Lewis*, Cook Heat Treating Co. of Texas

Mysterious Failures in Heat Treating (and Their Solution)
By *Horace C. Knerr*, Metab Co.

9:00 A.M. Manger Hotel

Session on Tubing and Pipe

Magnetic Particle Inspection of Steel Tubing
By *Robert G. Strother*, Magnaflux Corp.

Radiographic Evaluation of Stainless, Inconel and Titanium Tubing
By *Jack A. Kramer*, NTH Products, Inc.

Inspection of Welded Aluminum Tubing With Eddy Currents
By *D. E. Kunkle*, Aluminum Co. of America

Some Uses for a Precision Magnetic-Field Meter
By *R. A. Betz*, Westinghouse Electric Corp.

Radiographic Inspection of Thin-Wall Small-Diameter Tubing
By *G. M. Tolson and A. Taboada*, Oak Ridge National Laboratory

9:30 A.M. National Advisory Committee for Aeronautics

Session on Aircraft

Research on Materials for Aircraft Nuclear Reactors

Research on Materials for Power Plants for Aircraft

10:00 A.M. Wade Park Manor

Seminar on Residual Stresses I – Definition and Origin

Lecturer:
R. Weck, Cambridge University (England)

Commentators:
H. R. Neifert, Timken Roller Bearing Co.
and *J. A. Halgren*, International Harvester Co.

Thursday Afternoon, October 30, 1958

1:30 P.M. Wade Park Manor

Seminar on Residual Stresses. II — Measurement of Residual Stresses

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
E. S. Rowland, Timken Roller Bearing Co., *Ray L. Mattson*, General Motors Technical Center, and *George A. Butz*, Aluminum Co. of America

2:00 P.M. Statler-Hilton

Second Session on Titanium

The Effect of Heat Treatment on the Elevated Temperature Stress Stability of Titanium Alloys
By *M. L. Greenlee, G. A. Lenning, W. M. Parris* and *H. D. Kessler*, Titanium Metals Corp. of America

The Effect of Stress on the Eutectoid Decomposition of Titanium-Chromium Alloys
By *A. W. Goldenstein, A. G. Metcalfe* and *W. Rostoker*, Armour Research Foundation

Microstructure and Mechanical Properties of Ti-Cu-Al and Ti-Cu-Al-Sn Alloys
By *R. F. Bunshah* and *H. Margolin*, New York University

The Influence of Forging Temperature in Mechanical Properties of Al-V-Ti Alloys
By *L. S. Croan* and *F. J. Rizzitano*, Watertown Arsenal Laboratories

A Contribution to the Hardenability Problem in Titanium Alloys
By *R. P. Elliott* and *W. Rostoker*, Armour Research Foundation

2:00 P.M. Hotel Cleveland

The Metallurgist Looks at Nonmetallic Materials

Plastics
By *K. F. Charter*, A. O. Smith Corp.

Ceramics
By Representative of Ceramics for Industry

Cermets
By *Malcolm Judkins*, Firth Sterling, Inc.

2:00 P.M. Manger Hotel

Session on Steel and Heavy Metals

Causes of Ultrasonic Attenuation in 1013 Steel
By *Rohn Truell*, Brown University

Ultrasonic Testing Procedures
By *Jack D. Morgan*, Allegheny Ludlum Steel Corp.

Correlation of Ultrasonic Indications and Properties of High-Strength Steels
By *Charles F. Raatz, Jr.*, Boeing Airplane Co.

Atomic Energy Commission's Licensing Requirements for Use of Isotopes
By *James W. Hitch*, U. S. Atomic Energy Commission

Beam Deflector for Ultrasonic Inspection of Bronze Castings
By *N. J. Socoloski*, Curtiss-Wright Propeller Div.

Economics of Ultrasonic Testing
By *Howard McFaul* and *Cleo Webb*, Douglas Aircraft Co.

Thursday Evening

6:00 P.M. Cleveland Engineering and Scientific Center

Banquet With Cleveland Chapter, S.L.A.

7:30 P.M. Statler-Hilton

A.S.M. Annual Banquet

Friday Morning, October 31, 1958

9:00 A.M. Manger Hotel

Session on Standards for Nondestructive Testing

The Percent Ring Method for Eddy-Current Acceptance Standards
By *Hamilton Migel*, Magnaflux Corp.

Standards for Electromagnetic Testing Steel Tubing in Production
By *Fred A. Meunier*, Republic Steel Corp.

Radiographic Standards for Aluminum and Magnesium Castings
By *B. R. Swarts*, Convair Div. of General Dynamics

Ultrasonic Attenuation in Various Alloy Steels
By *Charles J. Adams*, Rocketdyne Inc.

Recent Applications of Eddy Currents for Inspection in the Field
By *Vernon Wiegand* and *Wm. Bodenstein*, General Electric Co.

Standard Samples and Procedures for Electromagnetic Testing of Tubing
By *Henry E. Babb*, Metrol Inc.

9:30 A.M. Public Auditorium

Panel on Metals Meet the Competition
By *Grant Clark*, Reynolds Metals Co., *A. B. McKee*, Aluminum Co. of America, *F. A. Loebach*, Kaiser Aluminum & Chemical Sales, Inc., *J. D. Briggs*, Bethlehem Steel Co., Inc.

10:30 A.M. Wade Park Manor

Seminar on Residual Stresses

III—Influence of Residual Stress on Deformation, Static Strength and Dimensional Stability

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
H. J. Noble, Pratt & Whitney Aircraft
E. S. Rowland, Timken Roller Bearing Co.

Friday Afternoon, October 31, 1958

12:00 M. Public Auditorium, Ballroom

Distinguished Service Luncheon

For 25-Year Members and Invited Students

2:00 P.M. Wade Park Manor

Seminar on Residual Stresses
IV—Influence of Residual Stress on Fatigue Strength and Stress-Corrosion Cracking

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
Ray L. Mattson, General Motors Technical Center
Julius Heuschkel, Westinghouse Research Laboratories
Leo P. Tarasov, Norton Co.

2:00 P.M. Manger Hotel

Session on Ultrasonics

Implications of Ultrasonic Attenuation
By *J. K. White, R. W. McClung* and *J. W. Allen*, Oak Ridge National Laboratory

Typical Inclusions and Their Ultrasonic Responses
By *G. J. Binczewski*, Kaiser Aluminum & Chemical Corp.

An Ultrasonic Monitor
By *F. C. Panian*, Aluminum Co. of America

A Portable Device for Inspection of Plate and Small Forgings
By *C. W. Cline* and *S. G. Von Stocker*, Aluminum Co. of America

Inspection of Rocket Motors Using Solid Propellants
By *Murry E. Liebman*, Aerojet-General Corp.

Immersed Ultrasonic Testing Using Contoured and Focused Transducers
By *R. C. McMaster*, Automation Instruments, Inc.

Friday Evening

6:00 P.M. Public Auditorium

40th Annual Metal Exposition Closes

8:00 P.M. Wade Park Manor

Seminar on Residual Stresses
V—Relation Between Residual Stresses and Brittle Fracture

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
Julius Heuschkel, Westinghouse Research Laboratories
W. M. Baldwin, Case Institute of Technology

Saturday, Nov. 1, 1958

10:30 A.M. Wade Park Manor

Seminar on Residual Stresses
VI – Relation Between Residual Stresses and Brittle Weldments

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
LaMotte Grover, Air Reduction Co.
W. M. Baldwin, Case Institute of Technology

2:00 P.M. Wade Park Manor

Seminar on Residual Stresses
VII – Methods for Stress Relieving

Lecturer:
R. Weck, Cambridge University (England)
Commentators:
Louis J. Larson, Allis-Chalmers Mfg. Co.
George A. Butz, Aluminum Co. of America
Closure:
J. O. Almen, Consulting Engineer, Honorary Chairman of the Seminar

General Note on the Seminar

The Seminar on Residual Stresses, Thursday, Friday and Saturday of Convention Week, is the second such enterprise of the American Society for Metals. (The first was held 18 months ago in Los Angeles and considered the Fabrication of Titanium).

The Seminar on Residual Stresses will consist of seven lectures by Prof. R. Weck, University Lecturer in Engineering at Cambridge University, England. They are adapted from a slightly longer course given in Cambridge and in several European countries during the last few years. The lecturer is also director of research for the British Welding Research Assoc. and is chairman of the International Institute of Welding's Commission on Residual Stresses.

A special feature of each meeting will be that Dr. Weck will lecture for an hour, and then two American engineers, expert in that particular branch of the subject, will occupy the platform and discuss the matter with the lecturer or with the audience.

After the last lecture the honorary chairman of the Seminar, J. O. Almen, noted for his work in the industrial application of shot peening of springs and other highly stressed parts to increase their service life, will present a general review.

All meetings are to be held at Wade Park Manor. Advance registration is necessary, since the hotel's capacity is limited.

Exhibitor Listing

A

Acetogen Gas Co. 2721
Acetogen gas process for cutting and scarfing; heating and welding tips.

Acheson Colloids Co. 2777
Dispersions of solid lubricants and liquid.

Acme Mfg. Co. 1111
Semi and automatic polishing, buffing, deburring and micro finishing machinery.

Acoustica Associates, Inc. 2866

Aeronautical Service-Engineering 2873
Shot peening of metallic parts.

Aeronautical Shot-Peening Service, Inc. 2873
Shot peening of metallic parts.

Ajax Electric Co. 1608
Salt bath furnace equipment; electrically heated industrial furnaces.

Ajax Electrothermic Corp. 1608
High-frequency induction furnaces.

Ajax Engineering Corp. 1608
Low-frequency, induction furnaces for melting.

Alco Products, Inc. 2207
Forgings made of ALCO Hi-Qua-Led steel, and demonstration of their machinability.

Aldridge Industrial Oils, Inc. 542
"Quenzine" quenching oil; "Beacon" heat treating supplies; lubricants for metal working.

Allison-Campbell Division, American Chain & Cable Co., Inc. 1933
Abrasive cutting wheels; wet and dry abrasive cutting machines.

Alloy Engineering & Casting Co. 1241
Heat resistant and corrosion resistant castings.

Aluminum Division of Olin Mathieson Chemical Corp. 1824

American Brake Shoe Co., Electro-Alloys Div. 215

American Cast Iron Pipe Co. 2201
Centrifugal castings.

American Chain & Cable Co., Inc. 1235, 1933
See Allison-Campbell Div. and Wilson Mechanical Instrument Div.

American Cystoscope Makers, Inc. 209
Borescopes, miniature lamps and optical flats.

American Gas Association 1924, 1930, 1933, 2023, 2027, 2033
Industrial gas furnaces, ovens and burners.

American Gas Furnace Co. 2027
Automatic heat treating equipment.

American Machine & Foundry Co. 2530
See DeWalt Div.

American Machine and Metals, Inc. 231
See Riehle Testing Machines Div.

American Machinist 2140
McGraw-Hill publication.

American Mat Corp. 2570
Mats—rubber, plastic, wood,

American Metal Market Co. 1745
Publisher of *American Metal Market* and *Metal Statistics.*

American Metal Repair Assoc. 1738
Industrial welding and brazing.

American Optical Co., Instrument Div. 1119
Metallographic and other optical scientific equipment used in the metal industry.

American Platinum & Silver Div. 2547
See Engelhard Industries, Inc.

American Pullmax Co., Inc. 2561
Universal shearing and forming machines.

American Silver Co., Inc. 920
Very thin, close-tolerance metal strip; silver brazing alloys; thermostat bimetals.

American Society for Metals 2032
Magazines, books, and educational courses for the metals industry.

Arcair Co. 2651
Torches and electrodes for gouging, cutting and metal removal.

Arcweld Mfg. Co. 1722
High-temperature, testing and creep testing equipment.

Associated Spring Corp. 1411
Precision springs and wire forms; small stampings; cold rolled specialty steels.

Automotive Industries Magazine 1402
See Chilton Publications.

B

Babcock & Wilcox Co., Tubular Products Div. 312
Seamless tubing and extrusions in carbon and stainless steels.

Baj Tool Co. 2567
Keys and key-way broaches.

Baker Platinum Div. of Engelhard Industries, Inc. 2547
Electrical contact materials, precious metal parts and cladding. Nitroneal generator.

Baldwin-Lima-Hamilton Corp. 942
"Servomatic" tensile machine, fatigue tester, creep machine and impact machine.

Bal-Tate Furnace Co. 1718
Gas-fired glass-bath for heating extrusion billets.

Balteau Electric Corp. 1033
Portable industrial X-ray units.

Barber-Colman Co., Wheelco Instruments Div. 2044
Recorders and controllers with combustion safeguards.

Barer Engineering & Mach. Co., Ltd. 2316
Lathes, drill presses, shapers and grinders.

Barry Controls Inc. 2632
Noise dampeners; leveling mounts for metal working machinery.

Bath E., Cyril 402
Radial draw forming; sheet metal parts formed in titanium, stainless, hastelloy, aluminum and all heat resistant alloys.

Battelle Memorial Inst. 1012, 1016
Industrial research; Cobalt Information Center; American representative of Tin Research Institute, Inc.

Bausch & Lomb Optical Co. 2557
Metallographic equipment; optical instruments.

Beckett-Harcum Co. 2508
See Pneu-Hydraulics, Inc.

Bedford Gear & Machine Products, Inc. 1204
Precision gears and spline shafts, automatic drill heads, chuck jaws, gages.

Beryllium Corp. 910
Beryllium-copper alloys; commercially pure beryllium; chemical compounds.

Binks Mfg. Co. 1501
Paint spraying equipment; water cooling towers.

Bix Co. 536
Articulated heat treating fixtures and baskets.

Black & Decker Mfg. Co. 2621
Portable electric tools; drills, grinders, hand tools.

Blakeslee & Co., G. S. 1120
Metal cleaning equipment; ultrasonic cleaners.

Branson Instruments, Inc.; Branson Ultrasonic Corp. 1110
Ultrasonic generators, testing equipment, thickness gages, cleaning equipment.

Brinkmann Instruments, Inc. 2746
Dilatometers, balances, microscopes, metallographs, thermostats.

British Industries Corp. 2522
Die casting machines; Shaw process for precision casting; investment "X" casting process.

Brown & Sharpe Mfg. Co. 2434

Brush Beryllium Co. 530
Beryllium metal and fabricated shapes; Be-Cu castings, strip, master alloy; beryllium oxide refractories.

Buck Mfg. Co. 2673
Electromagnetic clamping equipment; drill presses.

Budd Co., Nuclear Systems Div. 2108, 2134
Gamma radiation sources for industrial radiography. See also Tatnall Measuring Systems Co.

Buehler Ltd. 431
Equipment for preparation of metallographic specimens; microscopes; metallographs.

Burgess & Associates, Inc. 2766
"Vibron" pneumatic vibrators and bulk material feeders.

C

C. I. T. Corp. 1615
Instalment finance service.

Cadillac Stamp Co. 1528

Cady, P. L. 2568
Cady double apron brakes.

Cam-Lok Div., Empire Products, Inc. 1039
Welding accessories; cable connectors, terminal lugs, electrode holders.

Camman Mfg. Co. 1737

Center for Documentation and Communication Research, Western Reserve University
Abstracting and indexing; machine literature searching systems.

Centrifugally Cast Products Div. 2330
See Shenango Furnace Co.

Challenge Machinery Co. 1730
Toolroom equipment, floor plates and layout tables.

Chapman Valve Mfg. Co. 405

Chilton Publications 1402
Publishers of *Iron Age, Automotive Industries, Aircraft and Missile Mfg.*, and other business magazines.

Cincinnati Sub Zero Products 2864
Chilling machines; low-temperature testing equipment.

Cleveland Instrument Co. 1137
Diamond gages (electronic); automatic gaging equipment, machine- and numerical-control equipment.

Clino Arc and Vacuum Furnaces 2522
See British Industries Corp.

Cobalt Information Center 1012
Educational exhibit on uses of cobalt metal, alloys and chemicals.

Collins Microflat Co. 532
Black granite surface plates.

Columbus Automatic Lubrication Co. 2876
Equipment for lubricating dies for press, upset and hammer forging, for die casting and for glass molding.

Consolidated Electrodynamics Corp. 2841
Furnaces, gages and other high-vacuum equipment.

Cooper Metallurgical Associates 1212
Boron and its products; borides.

Curtiss-Wright Corp. 1840
Ultrasonic equipment; heat testing; extrusions, forgings and castings.

Cushman & Denison Mfg. Co., Inc. 2719
"Flo-Master" felt tip pens; marking inks.

D

DCMT Die Casting Machines 2522
See British Industries Corp.

Dake Corp. 2749
Arbor and hydraulic presses; guided platen presses.

Daystrom, Inc. 1240
See Weston Electrical Instrument Corp.

Dayton Perforators, Inc. 2765
Standard and special piercing punches and insert dies.

Despatch Oven Co. 2848
Industrial furnaces.

Detrex Chemical Industries, Inc. 1907
Equipment and supplies for degreasing, sonic cleaning, alkali and emulsion cleaning, phosphate coating.

Detroit Testing Machine Co. 2423
Hardness, tensile and ductility testers.

DeWalt Division, American Machine & Foundry Co. 2530
Aluminum cutting machine, with power cross feed and automatic mist generator.

Diamond Saw Works, Inc. 2234
Hand and power hack saw blades, metal-cutting band saw blades.

Disston Div. of H. K. Porter Co., Inc. 2618
Industrial metal-cutting saws, hack saws and blades, band saws, electric hand saws.

Doehler-Jarvis Div. of National Lead Co. 2024
Die castings.

Dow Chemical Co. 1029
Magnesium products; cleaning solvents.

Driver Co., Wilbur B. 306
Precision alloys for electronic, electrical, chemical and mechanical applications.

Drop Forging Assoc. 1812
Drop forgings for superior service.

Dry Clime Lamp Corp. 2329
Infra-red ovens and dryers.

du Pont de Nemours & Co., Inc., E. I. 522
Industrial rivets; degreasing compounds.

E

Easco Products Div. of Electro Arc Sales Co. 930

Eastman Kodak Co. 1509
"X-omat" automatic film processor; optical gages, in-plant photographic equipment.

Electric Furnace Co. 1047
Industrial furnaces, atmosphere generators and auxiliaries.

Electro-Alloys Div. of American Brake Shoe Co. 215
Heat resistant alloy castings, shell mold casting and mold, retort.

Electro Arc Sales Co. 930
Arc metal disintegrators, electrical discharge machines, portable nibblers, etcher & demagnetizer.

Electro Metallurgical Co. (Div. of Union Carbide Corp.) 1622
Titanium, chromium, manganese and ferro-alloys.

Elgin Metalformers Corp. 2411
Modular cabinets for electronic instruments.

Elox Corp. of Michigan 1512
Electrical discharge equipment for die sinking and piercing holes in hard metals.

Empire Products, Inc. 1039
See Cam-Lok Div.

Enamelstrip Corp. (Div. of National Steel Corp.) 2112
Precoated steel in coils.

Engelhard Industries, Inc. 2547
Minoxo indicator, Dual Puridryer, Nitroneal generator, fused quartz and silicaware.

Exomet, Inc. 2515
Exothermic products, custom-made alloys, gas detector, insulation.

F

Fawick Airflex Div. of Fawick Corp. 2526
Airflex and magnetic clutches (in operation).

Fenn Mfg. Co. 1609
Combination two-high, four-high rolling mills.

Fenway Machine Co., Inc. 1741
Nibblers and portable electric and pneumatic metal-cutting tools.

Ferrotherm Co. 505
Brazed aircraft components; "Pin-Fin" heat exchangers.

Fisher Scientific Co. 2671
"Serfass" analyzer for determining gases in metals.

Foamalum Corp. 2718
Porous aluminum castings.

Forest City Foundries Co. 2817
Grey iron castings.

Fulton Foundry & Machine Co., Inc. 2753
Meehanite castings.

G

Gas Appliance Service, Inc. 1934
Gas fired heating equipment.

General Alloys Co. 351
Alloy castings and fabrications; furnace parts; heat treating fixtures.

General Fireproofing Co. 2240
Metal drafting tables and office furniture.

General Ultrasonics Co. 2866
Ultrasonic cleaning equipment.

Gray Co., Inc. 2512
Paint spraying equipment; pumps for mastics.

Gries Industries, Inc. 915
Testing machines.

Gries Reproducer Corp. 550
Die cast and molded parts, metal and plastic fasteners, electronic hardware.

Grob, Inc. 1631
Band saws.

Grotnes Machine Works, Inc. 2414
Hydraulic expander.

Gulf Oil Corp. 1234
Oils and lubricants for the metal industry; quenching oils.

Gulton Industries, Inc. 2871
Ultrasonic equipment.

H

H. P. L. Mfg. Co. 1829
Metal stamping (small lots).

Hacker & Co., Inc., William J. 1912
Metallographic equipment.

Hammond Machinery Builders, Inc. 1250
Grinding and polishing machinery.

Harper Electric Furnace Corp. 1211
Industrial electric furnaces.

Harris Refrigeration Co. 1747
Low-temperature industrial chilling equipment.

Harshaw Scientific Div. of Harshaw Chemical Co. 1017

Hayes, Inc., C. I. 1726
Heat treating furnaces, gas burners, atmosphere generators.

Haynes Stellite Co., Div. of Union Carbide Corp. 1622
Heat and corrosion resistant metals, sheet, shapes, castings; hard facing materials.

Heil Process Equipment Corp. 2821
Tanks, heating units, ventilators for corrosive solutions.

Heli-Coil Corp. 1506
Screw-thread inserts; screw-lock inserts; thread repair kits.

Herculock Limited 1738
See American Metal Repair Asso.

Herscott Co. 1240
See Instrument Engineering and Combustion Co.

Hevi-Duty Electric Co. 241
Furnaces for heat processing.

High Vacuum Equipment Corp. 408
Laboratory vacuum furnaces, gage controls, diffusion pumps.

Hitchiner Mfg. Co., Inc. 1734
Precision investment castings.

Hones, Inc., Charles A. 1930
Industrial gas burners.

Honolulu Oil Corp. 2769
See Industrial Research Laboratories.

Houdaille Industries, Inc. 2521
See Wales-Strippit Co.

Houghton & Co., E. F. 1145
Compounds for cutting, forming and surface treatment of metals.

Howard Foundry Co. 212
Aircraft quality castings; castings for all manufacturing industries.

I

Illinois Testing Laboratories, Inc. 2629
Temperature, air velocity and dew point measuring and control instruments.

Index Industrial Corp. 2206
Machine tools.

Induction Heating Corp. 1203
Heating and special handling equipment.

Industrial Heating 2667
Monthly magazine.

Industrial Heating Equipment Co. 1035
Industrial furnaces for metal treatment.

Industrial Press 1729
Publishers of technical books and magazines.

Industrial Publishing Co. 2572
Publisher of *Industry and Welding, Precision Metal Molding, Welding Illustrated.*

Industrial Research Laboratories, Div. of Honolulu Oil Corp. 2769
"Xaloy" bimetallic cylinders for wear and corrosion resistance; special alloys.

Industrial Welding & Brazing Co. 1738
See American Metal Repair Assoc.

Industry & Welding 2572
Trade publication: "Welding Directory."

Instron Engineering Corp. 2854
Tensile testing machines.

Instrument Engineering & Combustion Co. 1240

International Nickel Co. 445
Nickel and its alloys; ductile iron; plated items; welding products.

International Research & Development Corp. 1420
"IRD Systems" balancing equipment and vibration analyzers.

Ionic Electrostatic Corp. 2502
See Scientific Electric, Inc.

Ipsen Idustries, Inc. 330
Fast carburizing; industrial heat treating furnaces and atmosphere generators; dewpoint controls.

Iron Age 1402
Weekly news-magazine for the metal industries.

J

James Products Co. 1405
Drill sleeves and taper chuck cleaners.

Jarrell-Ash Co. 2517
Spectrometers and spectrographs.

Jiffy Disintegrators, Inc. 2424
Metal disintegrating machines.

Jones & Laughlin Steel Corp. 360
Precision cold-rolled strip and other steel mill products.

K

Kanthal Corp. 537
Resistors and resistance alloys for high-temperature furnaces.

Kawecki Chemical Co. 521

Kemp Mfg. Co., C. M. 2023
Industrial gas combustion equipment, atmosphere generators.

King Tester Corp. 416
Portable Brinell hardness testers, adapters and King Brinell microscopes.

Kinney Mfg. Div. of N.Y. Air Brake Co. 2635
Vacuum furnaces, metal evaporators, high-vacuum equipment.

Knight Models, Inc. 2663
Scale models and plant layouts.

Kolene Corp. 2647
"Kolene" products and processed parts.

L

L and C, Inc. 2666
See Porter Precision Products

L & L Mfg. Co. 2716
Electric kilns, heat treating furnaces.

Laboratory Equipment Corp. 1015
Analytical equipment for carbon, sulphur, phosphorus.

Lake Chemical Co. 1020
See Markal Co.

Lakeside Steel Improvement Co. 305
Model of forging plant; heat treated forgings.

Leeds & Northrup Co. 2324
Electronic recording and control devices; complete control systems; electric furnaces.

Leitz, Inc., E. 1326
Microscopes and accessories.

Lepel High Frequency Laboratories 2211
High-frequency induction heating equipment; atmosphere brazing equipment.

Lewis Machine Co. 1527
Wire straightening and cutting machines.

Lindberg Engineering Co. 331
Industrial heating and heat treating equipment.

Los Angeles Dept. of Water & Power 2622
Industrial Los Angeles.

Lufkin Rule Co. 454
Measuring tapes and rules; precision tools and indicators.

Lynchburg Foundry Co. 1104
Gray iron and ductile iron castings made in green sand or shell molds.

M

M.B.I. Export & Import, Ltd. 2144
"DIXI-60" and "DIXI-75" jig borers; small metal working tools and accessories.

Machine Tool Manufacturers Affiliates, Inc. 2616
Universal punch and shear; universal abrasive cutting-off machine.

Magnaflux Corp. 1216
Nondestructive testing systems.

Magnetic Analysis Corp. 1136
Multi-method and special equipment for magnetic analysis; comparators; demagnetizers.

Maintenance Engineering Corp. 1738
See American Metal Repair Assoc.

Makepiece Div., D. E. 2547
See Engelhard Industries, Inc.

Malayan Tin Bureau 460
Information on Straits tin; tin plate and other uses of tin.

Man-Au-Cycle Corp. of America 1621
See S&S Machinery Co.

Markal Co. 1020
Paint sticks, fluxes, protective coatings.

Martindale Electric Co. 201
Rotary burs, files and saws; etching equipment; portable blowers; dust masks.

McGraw-Hill Publishing Co. 2140
Publisher of *American Machinist* and other engineering and industrial magazines; books.

Mead Specialties Co. 2509
Air cylinders, air valves and other pneumatic devices.

Merit Products, Inc. 2430
Flap-type coated sheet polishing drums.

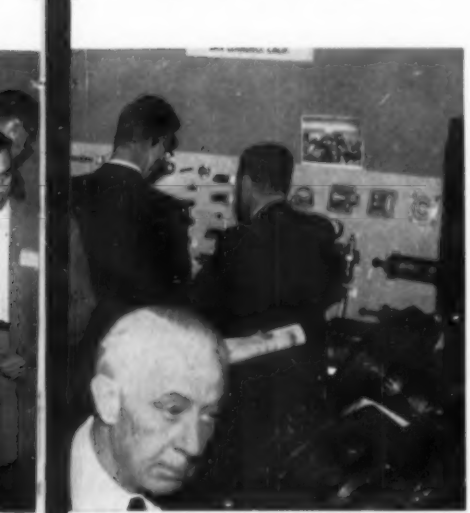
Metal Forming & Fabricating 2867
Publications by Watson Publications, Inc.

Metal Locking Service 1738
See American Metal Repair Assoc.

Metal Powder Assoc. 421
See Metal Powder Industries Federation.

Metal Powder Industries Federation 421
Powder metals and products made by powder metallurgy.

Metal Progress 2032
Monthly engineering publication for the metals industry.



Metal Removal Co. 2608
All-purpose abrasive.

Metals Engineering Institute 2032
Lesson courses (home study courses) on various aspects of the metals industry.

Metals Review 2032
Monthly news-magazine; includes "Review of Metal Literature."

Metalweld, Inc. 1738
See American Metal Repair Assoc.

Mettler Machine Tool Inc. 2750
Automatic wire straightening and cutting machine; wire reels; thread rolling machine.

Micrometrical Mfg. Co. 221
Electronic instruments for measuring roughness, waviness and lay.

Mine Safety Appliances Co. 1751
Atmosphere analyzers and combustion controllers.

Minneapolis-Honeywell Regulator Co. 1229
Industrial instruments and controls.

Missouri Division of Resources & Development 1129
Advantages of Missouri as a location for modern industry.

Moine Engineering Co. 1738
See American Metal Repair Assoc.

Monarch Tools, Inc. 2334
See Rankin Bros. Engineering & Sales, Inc.

N

NRC Equipment Corp. 1723
High-vacuum furnaces, coaters, components.

Narda Ultrasonics Corp. 2438
Cleaning, processing and machining equipment.

National Carbon Co., Subsidiary of Union Carbide Corp. 1622
Electrodes; carbon blocks; carbon products.

National Electric Instrument Div. 2547
See Engelhard Industries, Inc.

National Forge Co. 2410
Large steel forgings.

National Lead Co. 2024
Die castings; titanium alloys and castings.

National Malleable & Steel Castings Co. 1520
"HTM" (pearlitic malleable), steel and malleable castings.

National Research Corp. 1723
See NRC Equipment Corp.

National-Standard Co. 1908
Industrial wire cloth; flat spring steels; wire.

National Steel Corp., (Weirton Steel Div.) 2112

Newage Industries, Inc. 2865
Microhardness tester, portable hardness tester, clear plastic reinforced hose, power filing machine, metal etching pen.

New Hermes Engraving Machine Corp. 2571
Electro-etching equipment and Pantograph engraving machines.

New Rochelle Tool Co. 2770
See Yoder Co.

New York Air Brake Co. 2635
See Kinney Mfg. Div.

Nordson Corp. 1219
Airless spray painting equipment.

North American-Viking Drill Co. 554
High-speed, straight-shank, twist drills.

Nuclear Systems Div., Budd Co. 2108
Radiography machines and radiation facility.

Nylon Molded Products Corp. 2520

O

Oakite Products, Inc. 1230
Materials and equipment for cleaning and finishing metals, for machining and for grinding.

Ohio Crankshaft Co. 2116
Induction heating and heat treating equipment (automatic).

Olin Mathieson Chemical Corp., Aluminum Div. 1824
Aluminum products.

Olsen Testing Machine Co., Tinius 1146
Tensile testing machines and auxiliaries.

O'Neil-Irwin Mfg. Co. 260
Precision metal working machines, both hand operated and power driven.

P

Park Chemical Co. 510
Heat treating supplies; cutting and grinding compounds, rust preventatives.

Patterson Machine Co., George C. 1716
Wire straightening and cut-off machines.

Penton Publishing Co. 1519
Publishers of technical books and business magazines; *Steel, Foundry.*

Peterson Machine Tool, Inc. 2734
Equipment for inspection with magnetic particles.

Philips Electronics, Inc. 1009
Radiographs and spectrographs; X-ray diffraction units, accessories.

Phillips Mfg. Co. 1427
Metal cleaning equipment.

PIC Design Corp. 2852
Precision tools, gears, shafts.

Picker X-Ray Corp. 1421
Industrial X-ray equipment.

Pneu-Hydraulics, Inc. 2508
Tapping machines; quick-coupling swivel and rotary joints; air and hydraulic valves.

Portage Double Quick, Inc. 2145
Quick-change tools; cut-off, milling and boring tools; layout tables; comparators.

Porter Co., Inc., H. K. 2618
See Disston Div.

Porter Precision Products 2666
Head-type punches; die buttons; "Bal-Lok" punches and retainers.

Precision Shapes, Inc. 517
Continuously milled products.

Prutton Corp. 1916
Thread rolling machinery.

Pyrometer Instrument Co., Inc. 1043
Surface, radiation, immersion and indicating pyrometers.

R

Rameo Equipment Corp. 2456
See Randall Mfg. Co., Inc.

Randall Mfg. Co., Inc. 2456
Degreasers, phosphating washers, detergent tanks.

Rankin Bros. Engineering & Sales, Inc. 2332
Coated abrasive grinding machines; precision inspection equipment.

Ransburg Electro-Coating Corp. 1707
Novel electro-coating equipment.

Rapid Electric Co. 2540
Power rectifiers (selenium, germanium, silicon).

Raymond Corp. 2728
Electric trucks and other material handling machinery.

Renite Co. 1720
Lubrication engineers.

Richards Co., J. A. 2560
Die making equipment; benders; cutters.

Riehle Testing Machines Div. of American Machine & Metals, Inc. 231
Universal testing machines; fatigue and creep-rupture testing machines.

Rotherm Engineering Co., Inc. 2702
Revolving and expansion joints.

Royall Casting Repair Service 1738
See American Metal Repair Assoc.

Ryerson & Son, Inc., Joseph T. 411
Cut-to-order carbon and stainless steel (and aluminum) sheet and strip.

S

S & S Machinery Co. 1621
Lathes and other machine tools.

Scientific Electric, Inc. 2502
Electric induction and dielectric heaters; ionic-electrostatic spray equipment.

Scott Paper Co. 1330
Paper wipers, towels, tissues for industry.

Scottish Tool, Die & Metal Products Co. 2715
Metal working dies.

Sealol Corp. 2508
See Pneu-Hydraulics, Inc.

Selas Corp. of America 1924
Gas burners and heat treating furnaces.

Sentry Co. 936
"Diamond Block" atmosphere control; toolsteel heat treating furnaces; laboratory tube furnaces.

Service Diamond Tool Co. 1735
Diamond-penetrator hardness testing machines and accessories.

Shaw Process Precision Casting Div. 2522
See British Industries Corp.

Sheldon Machine Co., Inc. 1245
Variable speed drive lathe with automatic speed selector.

Shell Oil Co. 2646
Cutting and quenching oils.

Shenango Furnace Co., Centrifugally Cast Products Div. 2230
Centrifugal castings.

Sicburg Industries, Inc. 2701
"Tonsilkut" high-speed contoured milling machine.

Simplicity Engineering Co. 2650
Parts washing and conditioning machines; conveyers, feeders.

Skil Corp. 2312
Portable electric power tools, abrasives, and accessories.

Snap-Tite, Inc. 2508
See Pneu-Hydraulics, Inc.

Socony Mobil Oil Co., Inc. 2216
Lubrication engineering service.

Sonoflux Div. 2734
See Peterson Machine Tool, Inc.

South Chester Corp. 2102
Specialty fasteners.

Southco Div. 2102
See South Chester Corp.

Southern Extrusions, Inc. 1806
Aluminum extrusions of various shapes.

Special Libraries Assoc., Metals Division
Library services, documentation systems and classification.

Spee-Flo Mfg. Corp. 2656
Hot spray heater; paint pumps; airless spray equipment.

Spencer Turbine Co. 2033
Turbo compressors; pneumatic conveying machines, industrial vacuum cleaners.

Stanat Mfg. Co., Inc. 2333
Rolling mill; slitting and leveling machinery.

Standard Oil Co. (Ohio) 935
Industrial lubricants.

Star Expansion, Inc. 2850
Fasteners.

Starrett Co., L. S. 2546
Mechanics' measuring tools; precision instruments; hole saws, hack saws, band saws; band knives; ground toolsteel flats.

Steel 1519
Weekly magazine of news and industry.

Steel City Testing Machines, Inc. 442
Machines for making mechanical and physical tests on metals and alloys.

Stimpson Co., Inc., Edwin B. 311
Rivets; stampings; screw machine parts.

Stocker & Yale, Inc. 2860
Optical inspection and localized lighting devices.

Stokes Corp., F. J. 919
Equipment for melting and heat treating in high vacuum.

Struers Chemiske Laboratorium, H. 1912
Metallographic laboratory equipment.

Sunbeam Corp. (Industrial Furnace Div.) 2123
Gas carburizing and atmosphere quenching equipment; heat treating furnaces.

Superior Tube Co. 2529
Small-diameter metal tubing; drawn shapes (clad) for atomic reactor cores.

Supreme Products Corp. 2617
Chucks and other attachments for power drills.

Surface Combustion Corp. 321
Heat treating furnaces and accessories.

Sutton Engineering Co. 2751
Swaging machine, straighteners, extrusion presses, and processing machines.

Swedish Crucible Steel Co. 506
Electric steel and alloy castings.

T

Tatnall Measuring Systems Co. 2134
Universal testing machine, creep machine, strain gages, direct stress machine.

Tempil Corp. 422
Temperature-indicating materials.

Tensilkut Div. 2701
See Sieburg Industries.

Texas Co. 1602
Cutting and drawing compounds; industrial lubricants.

Thomas Publishing Co. 2819
Publisher of *Industrial Equipment News* and Thomas Register of American Manufacturers.

Tickle Engineering Works Inc., Arthur 914
"Alumicoat" and "Alumibond" processes.

Timken Roller Bearing Co. 1051
Seamless tubing; alloy steel bars; graphitic toolsteels; removable rock bits; tapered roller bearings.

Tin Research Institute, Inc. 1016
Information about tin and its applications.

Titanium Alloy Mfg. Div. 2024
See National Lead Co.

Tocco Div. 2116
See Ohio Crankshaft Co.

Torrington Mfg. Co. 1834
Spring coiling machines; spring testers.

Torsion Balance Co. 1724
Analytical and industrial balances, hardness testers and accessories.

Tubular Rivet and Stud Co. 2655
Rivets, automatic riveters, riveted assemblies; "Permanuts"; electrical contacts.

Turco Products, Inc. 2755
Industrial chemicals; "Chemmilling" compounds; phosphate coatings; aluminum conversion coatings.

U

Union Carbide Corp. 1622
See Electro Metallurgical Co. Haynes Stellite Co.; National Carbon Co.

United Scientific Co. 1038
See Unitron Instrument Div.

U. S. Automatic Corp. 1219
See Nordson Corp.

U. S. Electrical Motors, Inc. 1929
Motors, gearmotors, variable speed drives.

United Wire & Supply Corp. 1142
Tubes and wire of copper, aluminum, brass; brazing alloys.

Unitron Instrument Div., United Scientific Co. 1038
Microscopes, metallographs, optical instruments.

Universal Castings Corp. 2661
Nonferrous castings.

V

Vanadium Corp. of America 446
Ferroalloys, commercially pure metals; chemicals.

Vanco, Inc. 2233

Vanguard Engineering Co. 2732
Portable cranes and elevators; materials handling equipment; universal power propulsion unit.

Vibron Div. 2766
See Burgess & Assoc., Inc.

W

Wales-Strippit Co. 2521
Sheet metal fabricating and duplicating equipment.

Watson Publications, Inc. 2867
See *Metal Forming & Fabricating.*

Waukee Engineering Co. 2554
Flow meters, gas-air-mixers; industrial washing machines.

Weirton Steel Div. of National Steel Corp. 2112

Wells Mfg. Corp. 2011
Horizontal band sawing machines.

West Instrument Corp. 2615
Temperature indicators, controllers, recorders and auxiliaries.

Westinghouse Electric Corp. 1711
Furnaces; motors; controllers; gearing; special alloys.

Weston Electrical Instrument Corp. 206
Temperature recorders and controllers; electrical measuring instruments.

Wheelabrator Corp. 2761
Wet blast cleaning and metal finishing equipment.

Wheelco Instruments Div. of Barber-Colman Co. 2044
Automatic temperaturue control systems.

Wilson Mechanical Instrument Div. American Chain & Cable Co., Inc. 1235
Hardness testers — conventional and fully automatic.

Wyandotte Chemicals Corp. 2609
Chemicals for metal finishing.

Y

Yoder Co. 2770
High-frequency tube welding equipment.

Z

Zagar, Inc. 2573
Drill heads; printed circuit drilling machine, collets and collet fixtures.

Zeiss, Inc., Carl 1214
Scientific optical instruments.

Special Metal Month Feature

Preview of Space Metals

Paralleling the requirement for new materials for aircraft, missiles and satellites is the need to develop improved capabilities in the common metal systems. Here's a report on where we stand and future prospects in . . . Aluminum . . . Magnesium . . . Steels . . . Titanium . . . Beryllium . . . Superalloys . . . Refractory Metals . . . Ceramics and Cermets . . . Graphite . . . Composite Materials . . . Sandwich Construction . . . Surface Treatment and Coatings . . . (T24, 17-57)

WE HAVE ENTERED the space age. With it have come new methods of propulsion, new fuels and, most significant, new environments. These rapid advances in aircraft, missile systems, satellites and long-range plans for space flights have required a reappraisal of materials, fabricating methods, and design criteria. Ideally, we need a metal with high melting point, excellent strength and ductility, but with near zero density. Such an element might be called "Unobtainium"; it does not exist.

In a more serious vein, we find that we will have to rely to a great extent on classes of materials already developed to solve our current problems. We must improve their metallurgical properties and fabricating characteristics as rapidly as possible and design with them until new and radical materials can be discovered and developed.

Many of the exact requirements of materials are not clearly defined because we are still learning about environmental conditions under which they must operate. At any rate, high strength-to-density ratio and good long and short-time elevated-temperature properties are at the top of the list of requirements. Cryogenic properties are important and optimum weldability, brazability, and formability are needed because the selection of a material oftentimes must be governed by the ability to fabricate it.

The editors acknowledge the generous assistance of many people at the Materials Laboratory, Wright Air Development Center, Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, who cooperated in interviews and supplied material which helped greatly to make this article possible. Special credit is due Col. R. A. Jones, staff officer for materials research and development programs, USAF, L. D. Richardson, in charge of research and technical development branch, and R. R. Kennedy, supervisor of metals branch.

Fig. 1 — An Engineer Studies Problems of the X-15, Shown Shrouded for Security Reasons. The experimental research craft is expected to fly in 1959. The plane is designed to carry man to altitudes above 100 miles at speeds over 3600 miles per hr. At mach 4 (2720 miles per hr. above 35,000 ft.) skin temperatures reach about 1000° F.

Aluminum and Magnesium

Alloys of these metals have inherent properties which have made them useful in the past and which will make them useful in critical applications in the future. The most important of these is their low density. The penalties of weight are greatly multiplied when trying to break through the earth's atmosphere. The problems posed by elevated-temperature environments are the most serious.

One source of this environment is aerodynamic heating resulting from high speed in the dense atmosphere surrounding the earth. This is a problem encountered by vehicles leaving and re-entering the atmosphere and by high mach aircraft now under design which remain in the atmosphere. Figure 2 shows typical temperatures which may be reached by high-speed airframes. The equilibrium skin temperatures go up with increasing speed because of friction encountered as the structure moves through the air. As altitude increases, and, therefore, the density of the atmosphere decreases, the skin temperature also decreases until a minimum is reached. For example, a supersonic aircraft traveling 1600 miles per hr. at 50,000 ft. has a skin temperature of about 400° F. This is a good indication of materials problems in present aircraft. The leading edge temperature of a vehicle returning into the atmosphere at a speed of 18,000 miles per hr. – the orbiting velocity – would be many times higher.

Problems and Possibilities – Since aluminum melts at 1220° F. and magnesium at 1202° F., their use in many future applications is out of the question. Some of the higher strength aluminum and magnesium alloys get their maximum properties through heat treatment; reheating would cause a severe loss of strength. Even so, there are some encouraging points. The extreme temperature and loading conditions encountered in the leading edge and nose cone will probably not exist throughout the entire structure. Designs with cooling and insulation will undoubtedly be developed so that aluminum and magnesium alloys with superior elevated-temperature properties will be useful.

One proposed construction of this type (called the "double-wall" system) uses an aluminum airframe to which very small pipes have been added to carry a water coolant. As the water circulates, the heat absorbed produces steam which is expelled overboard. Around this structure, a layer of low-density fibrous insulation is placed to reduce significantly the heat entering the cooling system and also to reduce the coolant weight to a reasonable value. A light shell of temperature resistant metal is used to form the smooth contour. This shell is divided into small panels mounted so they can expand freely with temperature changes. No attempt is made to carry primary structural loads on the shell. With this system the primary load carrying structure stays at about 200° F., fixed by the boiling point of water, and there are no problems because of creep or thermal stresses. Another alternative is also possible. A thin, protective sheet of high-temperature metal which is separated from the load-carrying aluminum or magnesium structure by an insulating layer may permit an over-all design which is practical and lighter in weight.

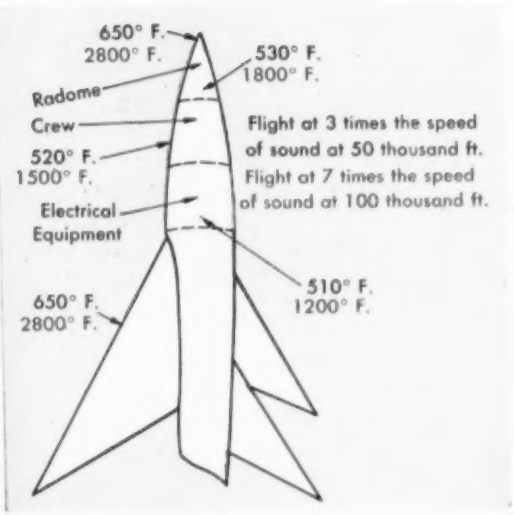


Fig. 2 – Typical Operating Temperatures of Airframes. The equilibrium skin temperatures go up with increasing speed because of friction encountered as the structure moves through the air. (Prepared by L. D. Richardson, Wright Air Development Center)

Best Alloys – Figure 4 shows the strength-to-weight ratios for the best aluminum and magnesium alloys for several temperature ranges. Alloy X 2020 T-6 is a new alloy containing copper

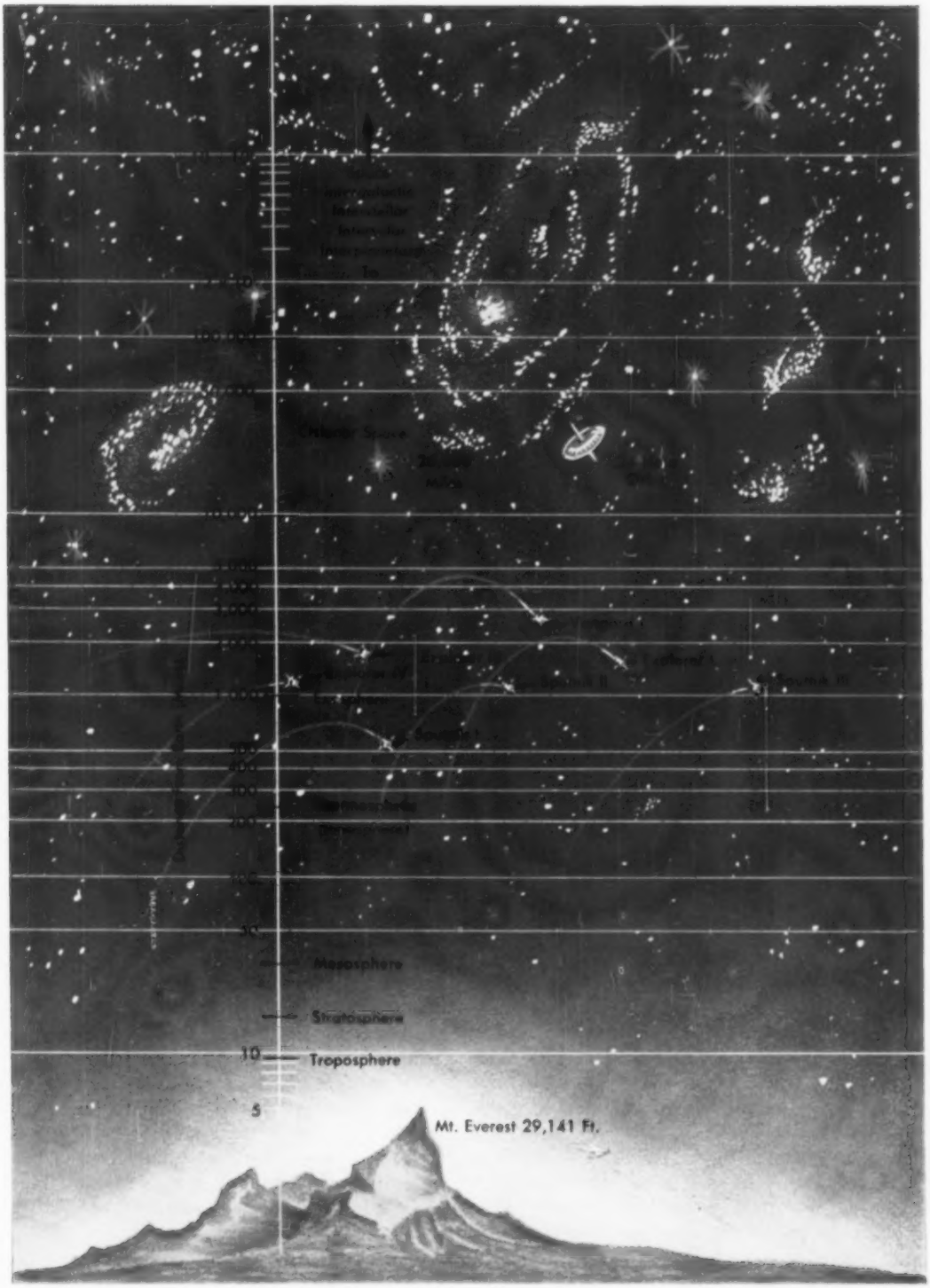


Fig. 3 – The Exploration of the Immensity of Space Will Call for Vehicles and Propulsion Systems With Characteristics Believed Unattainable a Short Time Ago. The materials which make up these vehicles must function reliably within an atmosphere which is in many ways different from that of earth

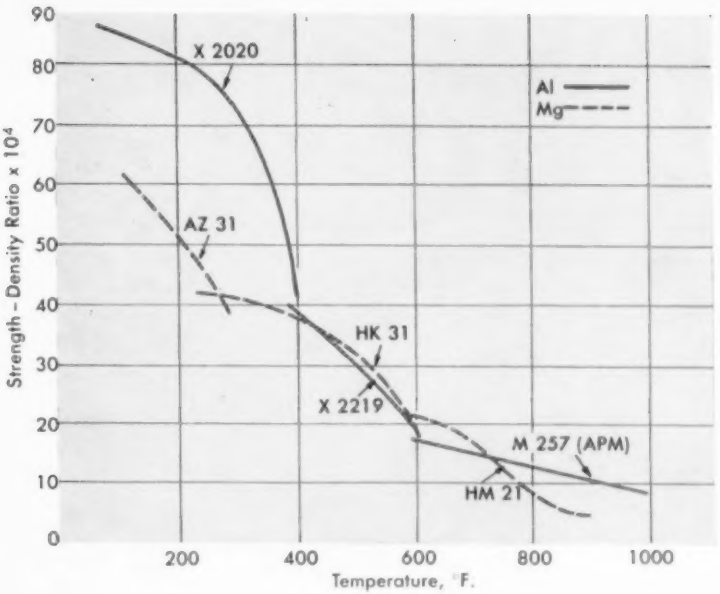


Fig. 4 – Capabilities of Today's Best Aluminum and Magnesium Alloys for Elevated-Temperature Applications. Strength - density ratio is ultimate strength in psi. to density in lb. per cu. in.

and lithium. Its room-temperature properties are somewhat higher than 7075 T-6 – which up to now has been the strongest standard aluminum alloy. Alloy X 2020 has superior tensile properties in the lower temperature range – up to almost 400° F. for 1000 hr. exposure. For shorter exposure time, its superiority is extended to over 400° F.

Alloy X 2020 is expected to become available in common wrought forms and it is being thoroughly evaluated by the Air Force and the aircraft industry. Its creep and rupture properties are superior to 2024 at 300° F., although they begin to approach each other at 400° F., as do their tensile properties.

Alloy X 2219 T-6, also shown in Fig. 4, was developed for elevated-temperature service. It's similar to the British alloy RR 57, which contains copper and manganese, but it also contains small amounts of vanadium and zirconium. It comes into its own in the range 400 to 600° F. At present, it is primarily a forging and extrusion alloy, although it can be rolled into sheets and plates.

A significant aluminum development has been the SAP, or sintered aluminum powder type of products, which utilize aluminum flakes containing various amounts of aluminum oxide. The properties of these products vary with particle size and volume of oxide they contain. One composition (shown in Fig. 4), designated M 257, contains 6 to 8% aluminum oxide by volume which is less than the 10 to 14% oxide of the original Swiss SAP.

These powder products are usable up to about 1000° F. The composition shown in Fig. 4 has a relatively low oxide content; consequently, it's easier to fabricate although its elevated-temperature properties are somewhat lower than the maximum which can be realized. The use of these products as honeycomb material is being investigated since they can be rolled into thin foil. The creep and rupture properties of the aluminum powder metallurgy products at 600° F. are superior to all conventional aluminum alloys.

Casting Alloy – A new aluminum casting alloy, XA 140, is still in the developmental stage. It has improved tensile and fatigue properties at 600° F. High-purity C 355 and A 356 can be cast using new methods which give higher properties in critical areas. This is expected to increase the use of aluminum castings in airframes and missile structures. A Federal specification on these two alloys in premium-strength castings for aircraft applications is now being prepared.

Magnesium – Alloys containing thorium have pushed the usable temperature of magnesium up to 900° F. for short-time low-stress applications – or within 300° F. of its melting point. Figure 4 shows the best magnesium alloys in their recommended temperature ranges. Alloy AZ-31, the standard sheet alloy, has the highest room-temperature properties, but it is exceeded in elevated-temperature properties by HK-31 H-24

in the range 300 to 550° F. and by HM-21 XA T-8 above 550° F.

Alloy HM-21 is exceptionally stable at elevated temperatures. For example, exposure for as long as 100 hr. at 700° F. has practically no effect on its properties at this temperature. Its creep properties at 400° F. and above, are better than HK-31.

Magnesium Castings – Thorium additions have also extended the temperature range for magnesium castings. EZ-33 is typical of the rare earth-zirconium alloys and HK-31 of the thorium-zirconium system. The former has applications in the 350 to 550° F. range, while the alloys containing thorium are definitely superior above 400° F. Magnesium alloys work out well for thin-walled castings; wall thicknesses as low as 3/32 in. are now approved for aircraft use.

Alloys ZK-60 and AZ-80 have been used extensively for forged aircraft wheels. They offer room-temperature ultimate strengths of 45,000 to 50,000 psi. and provide the stiffness needed for wheel applications with minimum weight. A recent investigation of forging alloys for higher temperature applications indicated EK-31 and HM-21 to be most promising for use up to 400° F. and above. Commercial forgings are now being made for further evaluation so data on properties can be made available to designers of high-speed aircraft and missiles.

Problems – If we look at the stength-to-weight ratios of the best aluminum and magnesium alloys for each temperature range (as shown in Fig. 4), we see how low the ratios are at the higher temperatures. The major challenge then is to improve property levels available at maximum usable temperatures.

There are more specific challenges: Designers say they need a good weldable aluminum alloy, which will have room-temperature properties in the metal as well as the weld, that are comparable to high-strength heat treatable alloys. It should also have good high-temperature properties. A better high-temperature fastener material or technique is needed for magnesium. If the modulus could be raised for both aluminum and magnesium, with no sacrifice in strength, then additional weight savings in many applications could be made. An experimental program showed that the modulus of aluminum could be raised as much as 35% by additional refractory carbides using powder metallurgy techniques. However, tensile strengths obtained were disappointing. It should be possible to accomplish more in this area.

Steels

As already noted we must rely on materials already developed for solutions to many of our airframe problems, pushing their capabilities as far as possible. High-strength steels fit into this picture. They offer good strength-to-weight ratio; some compositions offer promising elevated-temperature performance; they show evidence of fairly good ductility and fatigue characteristics.

The properties of steels heat treated to high hardness levels are constantly being improved. Refinements in heat treating practice have increased ductility in the 280,000 to 300,000-psi. range, for example, while studies of embrittlement have shown how to use alloys to best advantage. Compositions classed as hot work die steels have joined the ranks of metals receiving attention for moderate to fairly high-temperature applications. Until recently they were not considered a structural material.

Hot Work Toolsteels – These are classed generally as medium carbon compositions of the silicon-chromium-molybdenum-vanadium type. They are exemplified by such products as Peerless 56, Potomac M and VascoJet 1000 which show impressive tensile and yield strengths up to about 1000° F. They are better than the stainless steels, titanium alloys and currently available beryllium, on a strength-to-weight basis.

Fabrication difficulties are hampering the use of hot work die steels in structural applications. They are more susceptible to decarburization in heat treatment than other low-alloy steels. For the most part, welding without cracking is a ticklish operation and jigging for heat treating is normally a requirement because of the tendency toward dimensional changes. Machining in the hardened condition is also difficult. Another problem is developing rolling techniques for thin, close-tolerance sheet and foil for skin and sandwich construction. Also, oxidation and corrosion resistant coatings are needed. Diffusable coatings of aluminum or cadmium-nickel look promising and cladding with stainless 304, for example, may be effective.

Stainless types are an important class of materials for airframe construction. Even though they do not come up to the elevated-temperature strength of the toolsteels, their improved resistance to oxidation and corrosion is an important factor. The martensitic stainless group comes closest to matching the strength of the toolsteels

but lack oxidation and corrosion resistance and are plagued with fabrication problems. The precipitation hardening steels are easier to fabricate and are more heat resistant but they possess only about two thirds of the strength of the toolsteels used in these applications.

The modification of 17-7 PH to the new PH 15-7 Mo is an important step. The new composition gives a modest increase in tensile and yield strength, but more important it has creep properties from 25 to 100% better than 17-7 PH. The modification of AM 350 to AM 355 by slightly reducing chromium and using a 20% cold roll improves creep properties 10 to 25%, but more notably, increases the tensile strength by one third and the yield strength by one quarter.

B-70 Design – About 75% of the structure of the B-70, the strategic intercontinental bomber being designed to replace the B-52, a few years from now will be made of precipitation hardening stainless steels – probably PH 15-7 Mo and AM 355. Construction will be of the all-brazed honeycomb type, using large panels, perhaps approaching 10 × 20 ft. for a single piece. The remaining 25% of the structure is being planned for titanium alloys, principally the substructure – spars, ribs and bulkheads.

Charts in Fig. 5 show the present status of the high-strength structural steels. The dotted line in the chart represents results with experimental compositions which may give new capabilities with these materials. A number of modifications are being explored on the premise that a steel which can be tempered above 800 to 1000° F. with little loss of its high strength is likely to have good resistance to softening at these service temperatures. Empirical steel compositions being studied for higher tempering temperature resemble the hot work toolsteels now proposed for elevated-temperature structural applications.

Titanium

Its strength-to-density ratio is titanium's most publicized property. In this respect, it is superior to many metals over an intermediate, although wide, temperature range. Figure 6 gives a comparison of yield strength-to-density ratio as a function of temperature for titanium, beryllium and ferrous-base alloys. On this basis, the hot work die steels are the most competitive materials. Beryllium, with its low density, will be competitive when it becomes more available. The top curve in Fig. 6 represents the new all-beta titanium alloy. It has the potential of being heat treated to over 250,000 psi. ultimate tensile strength. In the laboratory, the alloy has been heat treated and cold worked to a tensile strength of over 270,000 psi.

The maximum temperature for use of titanium appears to be about 2000° F. for very short-time exposure and 1100° F. for long-time properties. Creep strength is not necessarily the limiting factor at high temperatures. Above 1100° F., titanium absorbs oxygen and nitrogen at rates sufficient to interfere with its usefulness. Some producers consider 1000° F. the upper limit for continuous service and 1500° for short-time.

Aircraft Versus Missiles – Isochronous creep curves, such as shown in Fig. 7 for Ti-5 Al-2.5 Sn, are used by designers in working with short and

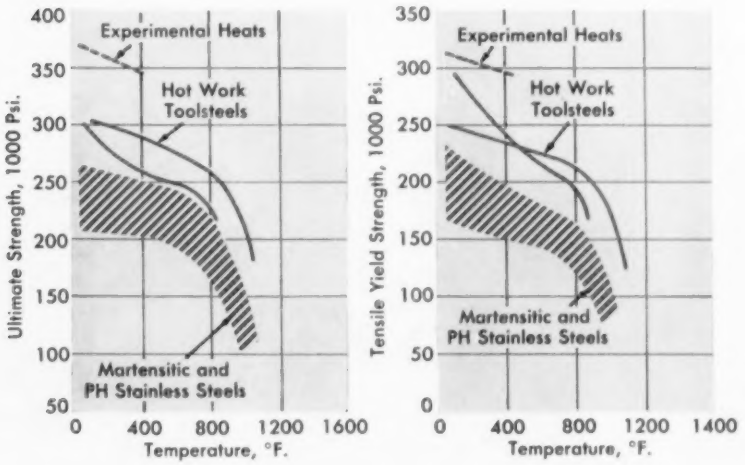
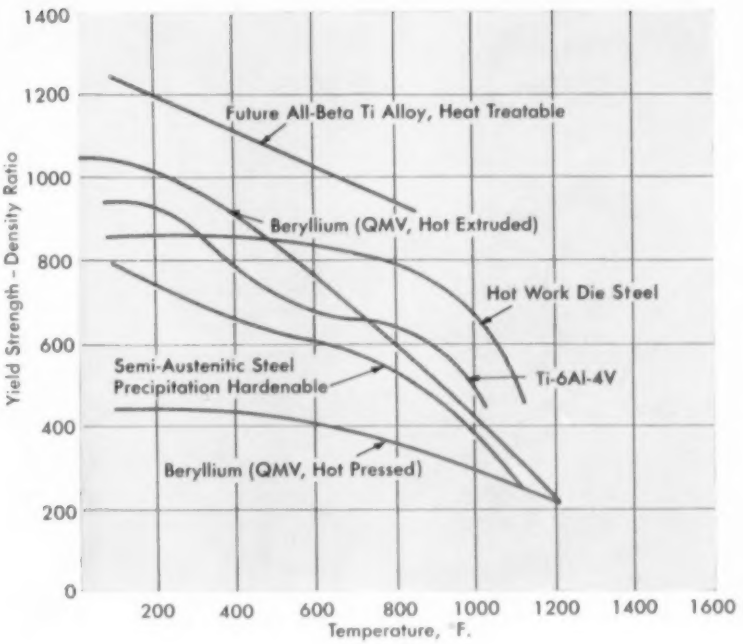


Fig. 5 – Strength of Steels Versus Temperatures. Dotted lines are experimental heats having compositions similar to hot work toolsteels

Fig. 6 – All-Beta Titanium Alloy Compared with Beryllium and Ferrous-Base Materials on a Strength-to-Density Basis at Elevated Temperatures. Strength-density ratio is yield strength in 1000 psi. to density in lb. per cu.in.



long-time creep data. For example, if a part were designed for an aircraft structure using Ti-5 Al-2.5 Sn, which was to have an allowable total deformation of 0.6% for 1000 hr. at an operating temperature of 900° F., the limiting stress would be about 18,000 psi. However, if the material were to be used for a missile structure, it could be used at a stress level of about 50,000 psi. for 1 hr. of exposure. Since titanium can withstand such high stress levels for short periods of time, it is an excellent metal for missile applications.

Low-Temperature Needs – Astronautics has created uses for titanium at cryogenic temperatures (Fig. 8). Several missile and rocket-powered vehicles store, pump and burn liquid fuels and oxidizers at very low temperatures – in the range –320 to –425° F. High pressures and impact forces are generally associated with cryogenic space applications. Strength-to-density relationship and impact resistance are most important in selecting a material for these uses. Although no data exist for titanium below –321° F., there are promising possibilities for alloy development. A characteristic of titanium is that it increases in strength as temperature decreases. Tests have shown that at –300° F. strength is double the room-temperature value.

Joining – Since many components of spacecraft are essentially flying pressure vessels, welding and brazing are important methods of construction. In the past year, a new titanium alloy was developed, the all-beta B 120 VCA, which appears to simplify brazing operations. A honey-

Fig. 7 – Isochronous Creep Curves for Ti-5 Al-2.5 Sn at 900° F. Since titanium can be used at high stress levels for a short time, it is a good material for missile applications

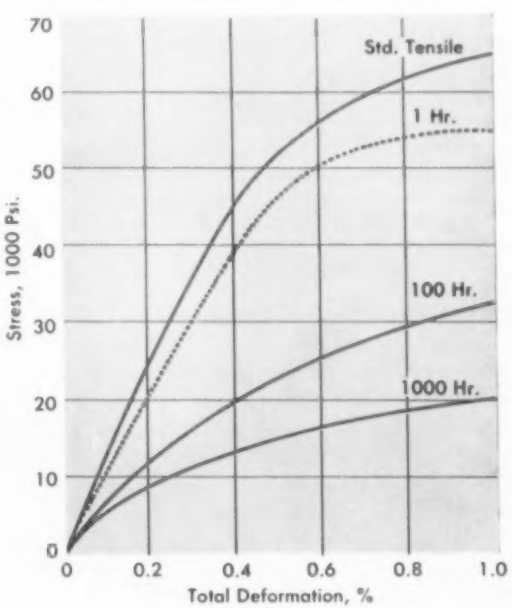


Fig. 8 – Missile Bottle Is Fabricated From Ti-6Al-4V for Use in the Atlas Missile. The 24-in. diameter sphere will hold liquid helium at —300° F. to help control propellant flow into the combustion chambers. Selection of titanium was based on four factors: weight savings, low-temperature properties, strength and corrosion resistance. (Courtesy Titanium Metals Corp. of America)

comb test piece fabricated from face and core materials of this alloy by a combination brazing and aging cycle gave a beam shear test result of 1245 psi. – the highest attained for any material. Tensile tests on similarly treated face sheet material showed 195,000 psi. ultimate tensile strength, 168,000 psi. yield strength and 6% elongation in 2 in. This test panel weighed about 2/3 as much as an equivalent 17-7 PH steel panel. If further evaluation verifies the test data, the development of titanium honeycomb could be a significant breakthrough for astronautical structures.

Beryllium

During the past year, progress made to develop structural beryllium has been tremendous. Today, it's no longer a laboratory curiosity. Instead, it is a metal which can be made into needed shapes and utilized in limited but important applications.

A unique advantage of beryllium is its great stiffness; with a modulus of elasticity of 42×10^6 psi., it tops many other metals including the

steels. The thermal properties of beryllium make it highly desirable for heat-sink applications. Its melting point of 2343° F. imparts a degree of optimism for high-temperature use. Also, its strength-to-weight ratio is extremely high; in fact, few metals can approach it.

Because of these advantages, beryllium is today being proposed for a number of applications and is already being used in several components. For example, inertial guidance parts require a material which is not only light in weight but dimensionally stable. A second proposed application, which utilizes the unusual thermal properties of beryllium and at the same time reduces weight, is aircraft brake disks. Here the metal would be a heat sink for the enormous amount of heat given off. Another proposed use is in missile nose cones and re-entry bodies. The thermal properties of beryllium, combined with lightness, would permit a weight savings which could be translated into either a range increase or fuel savings. Experimental nose cones have been produced from beryllium by powder metallurgy methods followed by precision machining to get a finished shape.

Problem Areas – Joining beryllium to itself and to other metals presents a problem, as does the entire area of fabrication when it is compared to the more common structural metals. The metal is toxic and specialized equipment is required when working with it (Fig. 9). Its cost is high; however, other factors, such as weight sav-

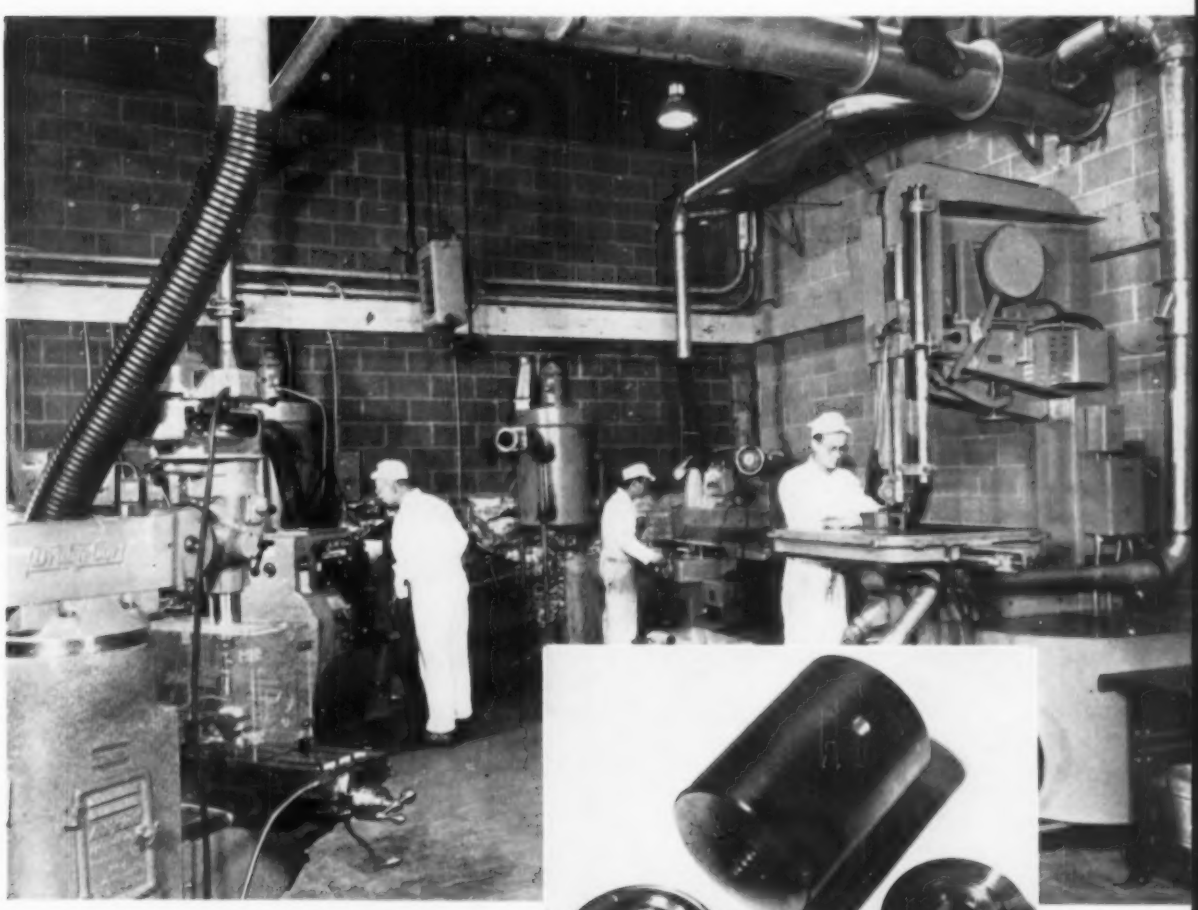


Fig. 9 – Pieces of Machined Beryllium Metal (Insert) and Setup for Machining Operation. Toxicity of the metal requires special handling. Beryllium is useful for inertial guidance components which demand a material light in weight and dimensionally stable. (Courtesy Beryllium Corp.)

ings, fuel savings and range increase must be carefully considered before cost can be fairly analyzed.

Because of the potential of beryllium as a metal, the Air Force has initiated a beryllium sheet rolling program. Although the program is still young, it has been found that rolling temperatures in the vicinity of 1400° F. give sheet with good strength and ductility in the plane of the sheet. The ultimate aim of the program is to produce sheets in sizes 30 by 60 in. by 0.020 in. thick. Fundamental investigations are being carried out to determine reasons for lack of ductility in beryllium and also to develop techniques for producing sound castings.

Superalloys

Superalloys will be called upon to furnish the bulk of heat resistant materials for the space age. Data so far indicate that all but certain "hot spots" may be within their capabilities. The possibility exists that these "hot spots" will be protected either by "cooled" superalloys or by coated refractory metals. At the present time, several new alloys are appearing which indicate potential usable properties at rather high stresses up to 1800° F.

There is little doubt that superalloys are reaching the limit of increase in temperature, while retaining present levels of load-carrying ability, because service temperatures are approaching the melting points of alloys of the chromium, nickel and cobalt systems. It seems that the most that can be expected is an increase of service temperature of some 100 to 200° F. The last increments will come slowly and will present difficult production and fabrication problems.

Power Plant Needs – Improvements in jet engine efficiency depend upon the development of alloys which can withstand greater stress at higher temperatures. This is placing great emphasis on better superalloys. Design curves for some of the strongest current alloys are shown in Fig. 10. Several nickel-base developmental alloys have outstanding stress-rupture strengths at 1800° F. Future advances in air-breathing engines, typified by the turbojet and ramjet, will probably be mostly of an improvement nature. They will depend largely on getting the last iota of performance out of materials which are compatible with existing design concepts.

A significant factor in the power plant picture today is the dominance of rockets for astronautics. The chemically fueled types, represented by those using red fuming nitric acid and ordinary jet fuel, have received the most attention. However, plumbing requirements and check-out complexity, plus ground servicing problems, may push them into the background. Solid fuel types are looking more promising all the time as a result of development of good propellant materials which can be cast directly into the casing. While these rockets are relatively simple in construction, they pose some serious materials problems due to severity of the operating environment and the need for the ultimate in weight reduction.

Two Problem Areas – Major advances are needed in at least two areas for air-breathing power plants. One is for nuclear-powered turbojet engines. This development has been delayed

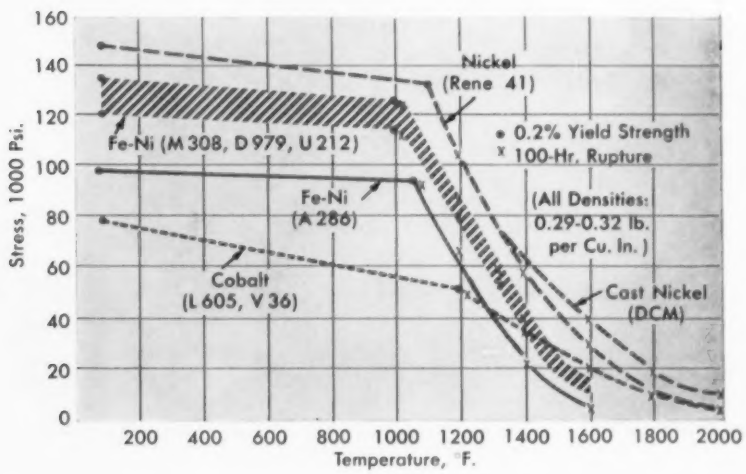


Fig. 10 – Design Curves for Some of Today's Strongest Superalloys. (Prepared by L. P. Jahnke and R. G. Frank, Aircraft Gas Turbine Div., General Electric Co.)

more by shortcomings of materials for fuel elements and heat exchangers than by any other single factor. Ionosphere ramjets, which have been proposed, will also present some challenging materials requirements. They will be large, but extremely lightweight, engines for operation in the upper reaches of the atmosphere. These engines will generate thrust by such means as compressing and catalyzing the available oxygen atoms so that they recombine into molecules. Materials problems will involve foil-like heat resistant structures and catalysts for the recombination process.

Space vehicles will also use heat resistant alloys in the form of thin sheet and tubular products. Designers are interested in short-time mechanical properties of the materials – such as creep-rupture data for 10 to 1800 sec. A need also exists for data on extremely long-time mechanical properties of superalloys. Space vehicles and space stations will be required to operate for several thousand hours.

Cooling Will Push Limits – It is reasonable to believe that cooling will be employed so that superalloys can be used at temperatures in excess of those normally allowable. At least two methods are available: One is air bleed-off for supersonic flight; another is liquid coolants for flight through the heat barrier into outer space and reentry into earth's atmosphere. Of the liquid coolants available, two methods are in the picture: The first is to circulate liquid fuel to absorb heat. This adds no weight to the structure. However, with solid propellants it will be necessary to carry an expendable liquid such as water which will escape as steam.

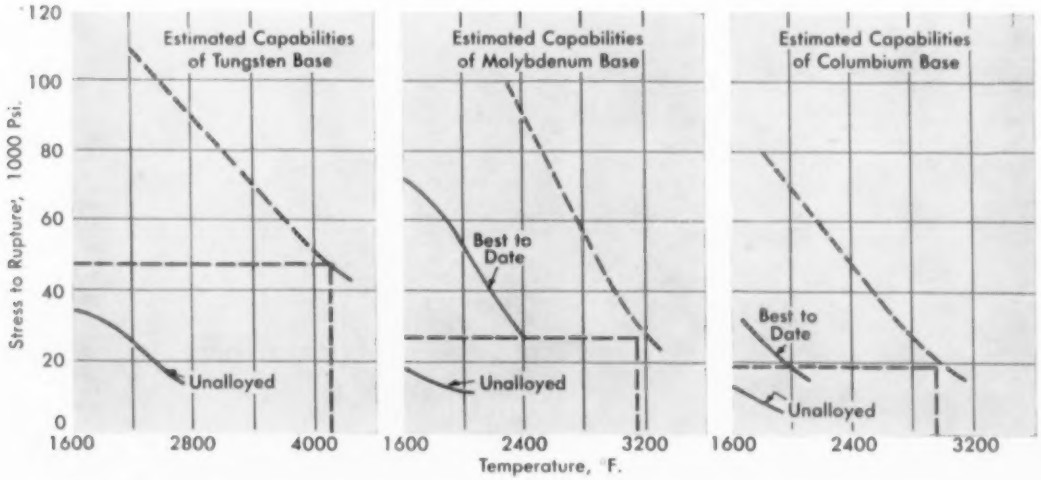
Refractory Metals

Ultra high-temperature problems most probably will be limited to the propulsion system and re-entry conditions. If we are to meet these conditions with materials which will respond to static and dynamic stresses in a ductile manner, we must turn to the group of metals having the highest melting points. These are the refractory metals – tungsten, tantalum, molybdenum and columbium.

Future capabilities predicted for the refractory metals are depicted graphically in Fig. 11, which shows the stress-temperature relationships for 100-hr. rupture life for the annealed, unalloyed metals tungsten, molybdenum and columbium. With molybdenum, alloy development has already raised its capability to a value of 0.55 of its absolute melting point. No data are available on tantalum but its high recrystallization temperature indicates a good high-temperature potential.

We are faced with a number of problems with the refractory metals. In some instances, we are only at the threshold of a problem; in others, considerable progress has been made. Take these two extremes: We know virtually nothing about arc melting of tungsten and very little about its atmospheric protection. On the other hand, arc-melted molybdenum and some of its alloys are commercially available and several protective treatments of varying degrees of re-

Fig. 11 – Predicted Capabilities of Future Refractory Metal Alloys Shown in Dotted Curves Based on Estimated 100-Hr. Creep-Rupture Behavior.



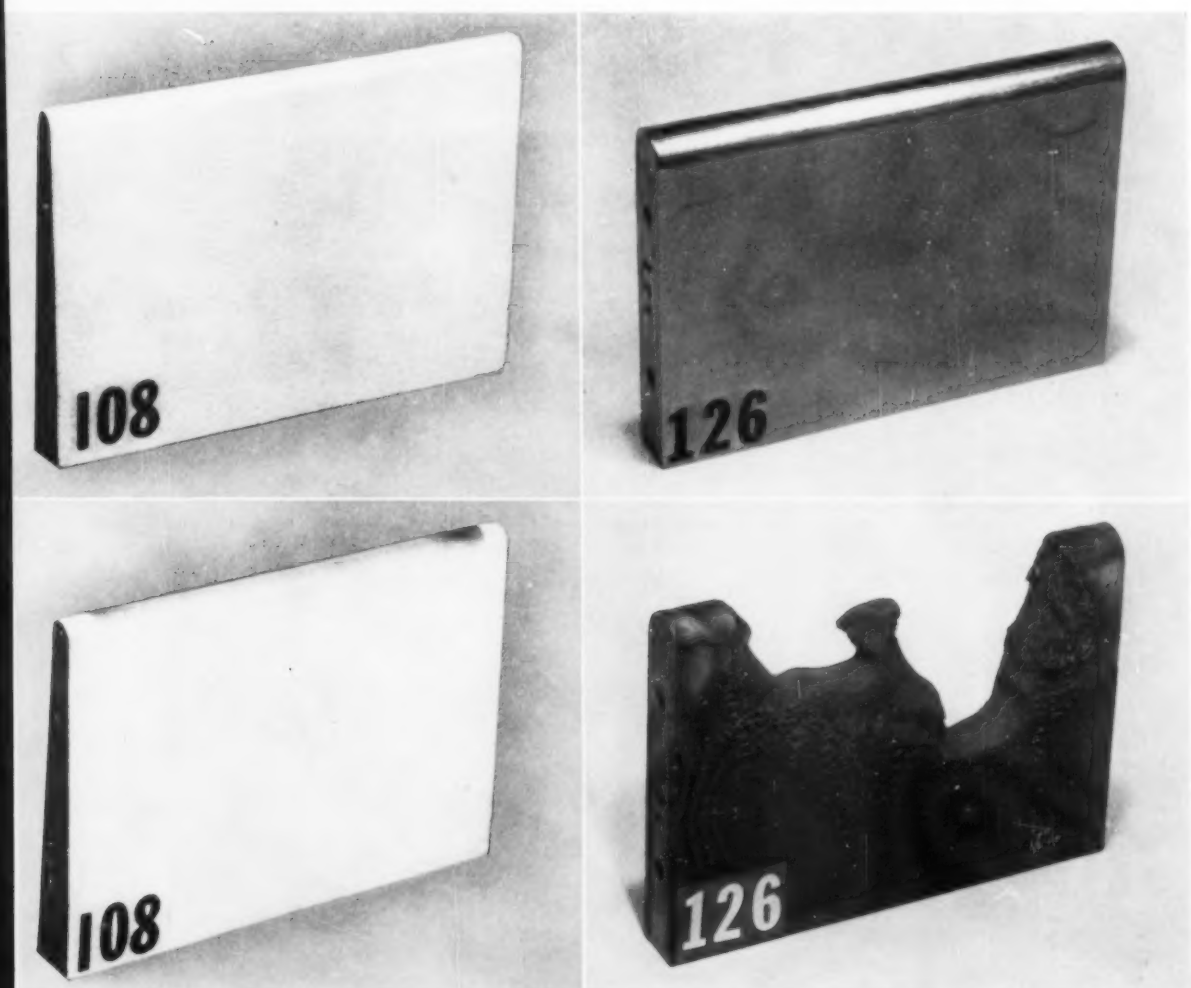
liability have been developed. Undoubtedly much has been learned about molybdenum which can be applied to the other refractory metals.

Protective Coatings – The biggest barrier to the use of the refractory metals is their low oxidation resistance. The strong efforts being made to use molybdenum in aircraft gas turbines have resulted in a number of coating techniques with different degrees of usefulness. The requirements to protect a gas-turbine bucket, which involve resistance to erosion, thermal cycling, high stress and impact for periods of 100 hr. or more, are such that it is difficult to find any single treatment or combination which will cope with all the conditions. Some of these techniques should meet requirements where exposure time will be shorter and some of the other stringent conditions of the turbine bucket will be avoided.

Ceramics and Cermets

A few years ago cermets looked promising for use in turbojet engines. Then a point was reached where superalloys approached (and in a few cases surpassed) the best of the titanium carbide-base cermets. As a result the problem of design with a brittle material was obviated. Now the question is: Are there jobs for ceramics and cermets in the space age?

Problems exist in the use of these materials as high-temperature structural components. For example, many ceramics which have fair resistance to thermal shock tend to oxidize at elevated temperatures. Those that don't oxidize have poor thermal shock resistance. There are sizable programs on ceramic-type materials for



rocket motors, rocket nozzles, leading edges and nose cones. Other applications are in guidance systems such as infrared transmitting windows and radomes.

Ductile Ceramics – Recent research has demonstrated that some ceramic-type materials are not inherently brittle. Magnesium oxide, sodium chloride and lithium fluoride can be very ductile. Freshly fractured specimens taken from single crystals show high ductility. Prolonged exposure of the fresh fracture to the atmosphere, however, destroys this ductility. There is the possibility that coatings, chemical dips, platings or other means of retaining this ductility can be developed. Another problem to be solved is how to build a ductile polycrystalline material from the ductile single crystals.

Graphite

Graphite is of interest in the astronautic age because it has potentially useful properties at 2700° F. and above. Figure 13 compares a commercial grade of graphite with tantalum and molybdenum by plotting tensile strength, corrected for density, versus temperature. It shows that graphite retains mechanical properties up to 5800° F. and its strength is superior to the refractory metals at 2700° F. If tungsten is compared on a density basis, it would need almost 50,000 psi. tensile strength at 4500° F. to compare with graphite.

Materials engineers working in problem areas will tell you that graphite is the most singularly attractive material proposed for high-temperature service. It is not unreasonable to expect it to find use for certain applications at 5000° F. It's of present interest for structures, rocket nozzles and components such as jetavators and jet vanes, leading edges for airfoils and thermal spikes, nose cones of the heat sink and ablation variety*, brushes, bearings and seals for high-temperature applications.

Although graphite is susceptible to oxidation and erosion in high-temperature air and combustion environments, for certain short-time applications the degree of degradation of unprotected graphite may not interfere with its performance. Structural use for relatively long times at high temperature under oxidizing conditions requires a coating. For certain applications, coatings are available which meet these requirements; however, a completely reliable, oxidation resistant coating, particularly under erosive conditions, does not exist today.

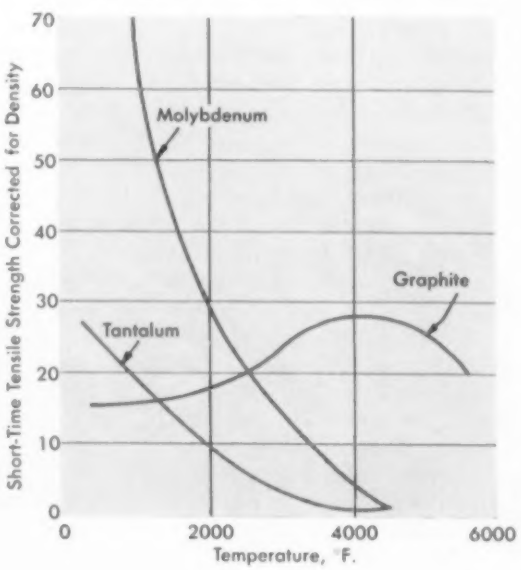
Fig. 12 – A Coated Molybdenum Specimen (108) Successfully Withstands a Rocket Exhaust of 4400° F. During a 20-Sec. Test. Gas velocity was 4600 miles per hr. Top photo shows piece before test, bottom one shows appearance after test. An uncoated Inconel specimen (126) fails initially by melting and then violently burns in the rocket exhaust at 3600° F. during a 19-sec. test. Gas velocity was 4600 miles per hr. Top photo shows specimen before test, bottom one shows it after test. Over 96 different materials have been tested; no uncoated metals survived the test. (Courtesy Cornell Aeronautical Laboratory)

Composite Materials

New and radically different composites are needed for future air and space vehicles. There is virtually no limit to the possible combinations.

*In aerospace terms, ablation is defined as a heat absorption and heat-transfer barrier phenomenon in which the ablating material may melt, vaporize, sublime, or depolymerize and in so doing is removed from the parent material.

Fig. 13 – Graphite Compared With Tantalum and Molybdenum on Basis of Tensile Strength, Corrected for Density, Versus Temperature. Graphite is expected to be a useful astronautic material for certain applications to 5000° F. This curve shows that tensile strength almost doubles in going from room temperatures to 4000° F.



Many multilayer configurations will be used. A lightweight composite inner layer can carry the load, while an insulated, cooled or otherwise resistant layer can be placed on the outside. If the load-carrying layer is sufficiently resistant, it may be on the outside and the insulated or cooled layer can be located on the inside to protect internal mechanisms, fuel and personnel.

Other approaches may be modeled after reinforced plastics, in which reinforcements with good tensile strength are supported in compression by matrix materials having low tensile strengths. For example, a material analogous to reinforced plastics is wire reinforced ceramic, or sheet metal strip wound around a suitable form and bonded with a structural adhesive.

Rocket Cases – Solid propellant rockets are assuming a more important role all the time in power plants for missiles and space craft. Since most of the nonpropellant weight is concentrated in the case and end closures, these items must receive prime consideration in the weight reduction effort. If a mass ratio of 0.90, for example, is to be obtained in a rocket containing 7000 lb. of propellant, then less than 800 lb. are available for the case, nozzle and other hardware. This is not much for a large pressure vessel designed to withstand upwards of 750 psi. with severe vibrations and perhaps external aerodynamic heating. Ordinary low-alloy steel, heat treated to 170,000 psi. yield strength, is not very attractive for these rocket cases.

The need for high strength plus the requirements for absolute concentricity has pointed the way to built-up strip or wrap construction. In the wrap process, several layers of thin ribbons of steel or other metal are helically wrapped around a mandrel and bonded with an adhesive. The end closure and nozzles may then be adhesive bonded to the case.

Steel strip, currently available, has a yield strength-to-density ratio of slightly less than one million. Certain steels, in strip form a few inches wide, can perhaps be heat treated to a yield strength of 300,000 to 400,000 psi. Heat treated titanium alloys and filament wound fiberglass-plastic also look good. These materials offer possibilities of strength-to-density ratios in the order of 1½ million or even more. Extensive work is needed to develop higher strength metals, fiberglass laminates and higher temperature adhesives to exploit the process. The possibilities are great and may ultimately lead to many applications other than rocket engines.

Fiber Metallurgy – Techniques are being studied to put metallic wires in a ductile metallic matrix. For example, molybdenum wires have been added to a matrix of Ti-6Al-4V by powder metallurgy techniques. Using 20% by volume of molybdenum wire, the strength of the composite at 1200° F. was equivalent to that of the straight titanium alloy at 600° F. The problem is to get the wires bonded without exceeding recrystallization or softening temperatures.

There are many other possibilities in the composite area. Reinforced plastics could be faced with metals to give increased rigidity and metals coated with reinforced plastics could dampen vibrations, improve fatigue resistance or perhaps provide an ablating material to resist thermal penetration. The theoretical strength and modulus of elasticity of long filaments (commonly called whiskers) are very high, indicating that composites using these materials should have excellent properties. There is the possibility of adding ceramic fibers to a ductile metallic matrix to give a composite with characteristics of both the ceramic and metallic materials.

Sandwich Structures

Composite construction, using present-day materials, gives strength properties equivalent to conventional construction with lower weight. Figure 14 shows the efficiencies of several metals comparing sandwich with conventional structures. Aluminum alloys are used for the lower temperature range, titanium alloys and stainless steel are shown for the intermediate range and at higher temperatures the efficiency of the superalloys is shown.

Design Advantages – Sandwich construction also gives specific design advantages which are becoming more important all the time. An example is resistance to sonic fatigue energy. In one test ,the maximum sound intensity resisted by a conventional structure was 167 db. and the plate panels lasted only 3 min. compared with sandwich panels which did not fail until they had been exposed for 460 hr. at the same sound intensity. The improved fatigue strength also helps resist failure due to aerodynamically induced vibrations.

There are other structural advantages: With proper selection of skin thickness and core cell, allowable buckling stress can be made equal to or slightly greater than the compressive yield stress of the facing material. More interior

volume is available due to elimination of bulkheads and ribs. Thermal conductivity can be controlled by proper selection of component materials. Smoother aerodynamic surfaces are possible since rivets and bolts are eliminated.

Sandwich and other adhesive-bonded configurations can function as fuel tanks. One flight vehicle has wings composed of sandwich construction with the core extending the full depth of the wing. The entire interior column of the wings is used to carry fuel. Other examples of structural sandwich applications are control surfaces, missile fins, missile fuel and oxidizer tanks, helicopter rotor blades, aircraft flooring, bulk heads. Nearly every advanced application requiring high strength and rigidity is a candidate for sandwich composites.

Coatings and Surface Treatment

The primary purpose of coatings for space applications is to control radiant heat transfer. Other requirements stem from the need for erosion control, lubrication and vibration damping. Satellite tests to date have shown that the erosion problem is not nearly as severe as was first imagined. Even so exterior coatings will have to contend with three types of environments. These are meteorites, charged particles and high-energy radiation. Work done on stabilization of coating materials for nuclear environments may be applicable to coatings for use under erosive conditions, except for the larger meteorites.

Vibration supression has been a big problem with aircraft, particularly with the large power plants. This problem will be greater with rocket power plants. Vibration can be damped most efficiently with a low-density coating, possessing high internal friction to vibration travel. Coatings such as silicone rubbers are efficient.

Lubrication – Another area, unique to space environments, is that of lubrication of unpressured components. In the atmosphere, metals have a thin oxide layer on their surface. If it is broken, it's quickly repaired by nature. In the absence of an atmosphere, damaged oxide films are not repaired and the rubbing surface will gall or weld. This means that nonvolatile, dry film lubricants may be necessary on all rubbing surfaces which are not protected.

Thermal insulation will have many uses in the space era. Ceramic coatings will be used to insulate structural parts from power plant and aerodynamic re-entry heat. Multiwall, polished metal surfaces, similar to thermos bottles, will be needed to protect cryogenic equipment and fuels.

Properties of Coatings – There is a need for coatings which will resist rocket oxidizers, but the most serious requirement is for coatings with heat, erosion and oxidation resistance for application to power plants. Metallo-organics seem to offer the brightest future in heat resistant paint-type coatings. Ferrocene type structures have heat resistance to 900° F. for short periods. Chelate polymers also look promising in the high-temperature field. Fluorocarbon materials are still rated the best for chemical resistance to oxidizers.

Electrical Systems – Here coatings problems are related to operation in an unpressurized environment. One problem is corona discharge which becomes most serious in the ionosphere

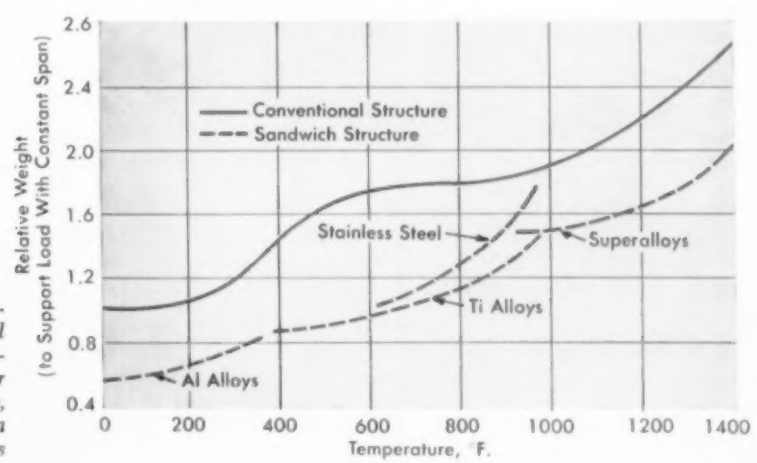


Fig. 14 – Weights of Conventional Structures Compared With Sandwich Type. In addition to less weight for equivalent strength porperties, composite construction has a number of other advantages

where all gases are easily ionized. Another potential problem is the volatility of metals at low pressures. A small evaporation of metal is sufficient to short circuit resistors and other electrical equipment. For example, cadmium plate may present a problem at temperatures as low as 200° F. This problem can be solved by avoiding the volatile metals or by constructing a shield around sensitive equipment.

Ceramic coatings with high thermal and oxidation stability are needed for protection of refractory metals in power-plant applications. Here the oxides, zirconates and silicates look promising. The borides, carbides and nitrides do not have inherent oxidation stability but in some cases the oxidation rate is low. Silicon monoxide is an example of a ceramic coating with self-healing properties.

Alloy plating and diffusion systems promise to give coatings with improved chemical and physical properties. The diffusion coating offers the best hope of providing a transition of properties between a refractory metal and an oxidation resistant topcoat.

The Changing Picture in Aircraft and Missile Metals

I — Airframe Alloys

Component	Now Used	Proposed for Future Use
Fuselage		
Structural members, frames, spars, longerons	Mg, Al, 4130 (40 R_c), Ti-6Al-4V, hot work die steels (55 R_c), 8740 (40 R_c)	4340 (50 R_c), hot work die steels (55 R_c), Ti-6Al-4V, Inconel X, M-252
Skins, panels	Mg, Al, Al honeycomb, 301, 316, 321, 410, 17-7 PH, 19-9 DL	PH 15-7 Mo, AM-355, A-286, 17-7 PH, brazed stainless honeycomb, 410, Inconel X, M-252
Attach fittings	303, 321, 4130 (40 R_c), 4140 (40 R_c), 4340 (40 R_c), 8630 (40 R_c), hot work die steels (50 R_c)	A-286, Inconel X, 4340 (55 R_c), hot work die steels (55 R_c), AM 350, AM 355, Ti Alloys
Wings		
Skins (sculptured)	Mg, Al, 301, 321, 17-7 PH, Ti	Brazed stainless honeycomb envelopes, 410, 17-7 PH, PH 15-7 Mo, AM 355, hot work die steels, 321, A-286, Inconel X, M-252.
Structural members	Mg, Al, 17-4 PH, 17-7 PH	17-4 Mo, 17-7 PH, AM 350, AM 355, hot work die steels (55 R_c), Ti alloys, A-286, Inconel X, M-252
Attach fittings	4140 (40 R_c), 4340 (40 R_c), Ti-6Al-4V, hot work die steels (55 R_c)	Hot work die steels (55 R_c), A-286, PH 15-7 Mo, 17-4 PH, 17-7 PH
Landing Gear		
Frames, rods	Al, 4340 (40 R_c), 8630 (40 R_c), 4340 (50 R_c), hot work die steels (55 R_c)	4340 (55 R_c), hot work die steels 55 (R_c)
Fittings, brackets	4340 (40 R_c), A-286, 410, HS-21	PH 15-7 Mo, A-286, 410
Hydraulic pumps	4340 (40 R_c), 410, 440	410, hot work die steels (55 R_c)
Brakes		Beryllium
Engine mounts	4340 (40 R_c), 410, A-286	A-286, 410, hot work die steels (55 R_c)
Empennage		
Skins	Al, 301, 321, 410, Ti	410, 17-4 PH, 17-7 PH, 19-9 DL, Inconel X, Ti-6Al-4V, hot work die steels (55 R_c), Ti alloys, A-286, M-252
Structural members	Al, 4340 (40 R_c), 8740 (40 R_c), 17-7 PH	17-4 PH, 17-7 PH, 4340 (55 R_c), AM 355, hot work die steels (55 R_c), Inconel X, A-286
Attach fittings	4140 (40 R_c), 4340 (40 R_c), 17-7 PH, AM 350, hot work die steels (55 R_c)	17-7 PH, AM 350, 4340 (55 R_c), hot work die steels (55 R_c), A-286

II – Jet Engine Alloys

Component	Now Used	Proposed for Future Use
Forward frame, gear boxes	1722 AV, Chromalloy, Mg-thorium alloy, 8740	17-7 PH, Ti-7Al-4Mo, Ti-6Al-4V
Hubs, shafts	4340, Ti-6Al-4V, AMS 6302, AMS 6304	A-286, 410, 431
Compressor disks	AMS 6302, AMS 6304, 410, 422, 431, 17-7 PH, Ti-6Al-4V, 4340 (32 R_c)	1722 AV, 410, 431, 17-7 PH, 19-9 DL, AM 350, A-286, Ti-6Al-4V, Ti-7Al-3Mo
Compressor rotor blades	410, 431, 17-7 PH, Ti	403, 17-7 PH, 19-9 DL, AM 350, A-286, Ti alloys
Compressor stator	410, 17-7 PH	403, 17-7 PH, PH 15-7 Mo, AM 350
Spacers	Ti-6Al-4V, 4340, A-286, 316	Inconel X, A-286, VascoJet 1000
Compressor housing	310, 321, Chromalloy, Mg-thorium alloy	Ti-5Al-2.5Sn, A-286
Center main bearing support	310, A-286	A-286, R-235
Combustion chamber manifold shrouds	310, N-155, A-286, Hastelloy B	R-235, HS-25, René 41
Turbine inlet nozzle	Hastelloy B	R-235
Turbine wheel	A-286, Discaloy, AMS 5616	A-286, M-308, Inconel 901, Waspalloy, D-979
Turbine shaft	A-286, 4340	A-286, Inconel 901, M-308, W 545
Turbine rotor blades	HS-31, M-252, U-500, A-286	U-500, U-600, U-700, Inconel 700, Inconel 713, GMR-235, GMR-235 D, HS-31, R-235, DCM, Nicrotung coated molybdenum
Turbine stator blades	A-286, HS-25, Hastelloy C, Refractaloy 80	René 41, Inconel 713, Inconel 700
Turbine stator case	A-286, N-155	R-235, René 41
Reheat burner	HS-25, N-155, 17-7 PH	René 41, Inconel 702
Rear main bearing support	A-286	Inconel X, Inconel W

III – Missile Alloys

Nose cone	303, 321, 17-7 PH	A-286, Be, Mo, graphite, ceramics, plastics, Cu
Skin	Mg, Al, 17-7 PH, 17-4 PH, 302, 321, Ti	17-7 PH, A-286, AM 350, AM 355, René 41, Ti alloys
Structural members	Al, Mg, 4340, 17-4 PH, 17-7 PH, Ti-6Al-4V	PH 15-7 Mo, 17-4 PH, 17-7 PH, A-286, hot work die steels (55 R_c)
Rings, attach fittings	4340 (50 R_c), 4330 (50 R_c), 410, 17-4 PH, 17-7 PH, 19-9 DL, Ti-6Al-4V	A-286, J-1570, M-252, R-235, Ti-6Al-4V, Ti-8Mn, Ti-16V-2.5Al, Ti B 120 VCA (beta), Ti-7Al-4Mo (alpha-beta)
Pressure tanks	4330, 4335, 4135, 4140 (50 R_c)	Hot work die steels (55 R_c), Ti alloys, Tricent
Fuel controls	Al, Mg, A-286	U-500, N-155, M-252, A-286, HS-25, S-816, U-600, U-700
Fuel control housing	Al, 301, 321, 347	A-286, René 41, R-235
Combustion chamber	17-7 PH, AM 350, AM 355	A-286, R-235, René 41, J-1570, M-252, Inconel 901, Inconel X
Tail cone assembly	17-7 PH, 19-9 DL, AM 350, AM 355	AM 350, AM 355, N-155, A-286, U-500, M-252, Inconel X, Graphite

Information in these tables is based in large part on a survey of 31 airframe, engine, missile and machine tool companies made by Curtiss-Wright Corp. for the Manufacturing Methods Branch, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio. Much of the information has been supplied by personnel of the Metals Branch, Materials Laboratory, WADC.

Special Metal Month Feature

What's New in Everyday Uses for Metals

Aluminum . . . Wrought Alloys

*By J. A. NOCK, JR., and F. KELLER**

A NUMBER of improved aluminum alloys have been developed for specific applications. These include: a unique high-strength alloy for aircraft and other structures; a group of intermediate-strength alloys for welded tanks and fabricated structures; several alloys for architectural uses; a new sheet and an extrusion alloy adapted to bright finishing for automotive and appliance trim; a nonstaining alloy for cooking utensils; two alloys for aluminum bus conductors; and two alloys for use with porcelain enamel finishes.

*Alcoa Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

For aircraft and other high-strength structures, an important development is alloy X 2020. It contains an appreciable amount of lithium and a small amount of cadmium which enables it to maintain high strength up to 400° F. Conventional aluminum alloys begin to lose strength when they are heated in the range of 250 to 350° F. Research on addition of lithium has shown that it not only serves to maintain the strength of the alloy at elevated temperature but decreases the density and also increases the modulus of elasticity about 8% over that of standard aluminum alloys. These two factors have made the use of X 2020 in airframe construction attractive even when high temperature is not involved.

More Higher Strength Alloys — In aircraft structures, the high-strength alloy 7075 has been used extensively as sheets, forgings, plates and extrusions. In thick extrusions and massive forgings, 7079, of more recent introduction, gives higher strength than 7075 because it is less susceptible to slow cooling rates prevailing in thick sections. In thinner sections and sheet, 7075

Large Aluminum Truck Tanks Fabricated by Welding Using One of the New Magnesium-Containing Alloys. Welded joints have good efficiency and show the same strength and ductility as the parent metal, in the annealed condition

develops measurably higher strength. Several modifications of these alloys have been announced recently, including X 7175, X 7275, X 7179 and X 7279. They were developed to provide the high tensile properties of these alloys in combination with increased elongation in the short transverse direction.

Another addition to the list of medium to high-strength heat treatable alloys is 6066. It gives strength levels intermediate between 6061 and alloys such as 2014 and 2024. It is recommended for structural applications.

Better Weldability – For many years, aluminum-magnesium alloys of intermediate strength have been used where the high-strength, heat treatable alloys were not suitable or economical. For large tanks, as an example, 5052 has been used extensively, while a higher strength alloy, 5056, was employed in the strain hardened temper for slide fastener elements and in alclad form for insect screening. With the development of inert-gas-shielded-arc methods for making high-quality welds, aluminum-magnesium alloys of this general type assumed considerable importance.* These alloys do not require heat treatment. Welded joints have good efficiency and show the same strength and ductility as the parent metal, in the annealed condition.

As a result of increased interest in the aluminum-magnesium alloys, six alloys of this type are now available: 5154, 5155, 5454, 5083, 5086 and 5456. They have nominal magnesium contents ranging from 2.75 to 5.25% and generally contain manganese and a small amount of chromium. Certain companion alloys such as 5556, X 5554, and 5183 are specifically recommended for weld filler materials. Products of these alloys (in certain tempers for each alloy) are recommended for marine applications, tanks, pressure vessels, truck bodies and other structures where weldability is important. Alloy 5454, because of its greater stability, is particularly adapted to applications operating in the range of 150 to 400° F.

Architectural Uses – Because of increased interest in curtain wall construction, several sheet and extruded products have been developed for use as building facing, panels and mullions. The products, which are aluminum-silicon alloys, are designated Anoclad 20, Anoclad 30 and Anoclad 40. They develop an attractive gray finish when a suitable anodic treatment is used. Several shades of a permanent gray finish ranging from a medium shade to a dark slate-gray, can be produced.

Bright Finish – One of the fastest growing uses for aluminum in the automotive field is for trim items such as grilles, exterior and interior panels, window frames, emblems and lettering. These parts are usually buffed, chemically polished, and then anodized to obtain a bright and protective finish. While alloys 1100, 3003 and 5357 have been used satisfactorily for some of these trim items, there has been a demand for alloys which would have a brighter and more metallic appearance after anodizing. To meet this need, two new alloys, 6463 for extrusions and X 5457 for sheet products, have been developed. Alloy 6463 is a heat treatable composition of the magnesium silicide type, similar to 6063. When anodically treated, it gives the brightest, clearest finish which can be achieved on a commercial aluminum extrusion without excessive cost. In addition to use in the automotive field, it should find applications in appliance trim and in architectural uses such as wall facings, store fronts, ornamental work, marquees, railings and ventilators.

The new sheet alloy, X 5457, is a companion

*"Development of Wrought Aluminum-Magnesium Alloys", by E. H. Dix, Jr., W. A. Anderson and M. Byron Shumaker, A.R.L. Technical Paper No. 14, Aluminum Company of America, 1958.

product to 6463. Its attractive appearance after buffing, brightening and anodizing makes it of particular interest for decorative trim applications in the automotive and appliance field. This new alloy is expected to replace 5357 for applications where maximum brightness is required. It offers bright lustrous finishes approaching those obtained with the much more expensive foreign alloys made from high-priced superpurity aluminum.

Nonstaining Alloy – For many years, cooking utensils have been made from 1100 and 3003 alloys. Under some conditions of use and with the type of water in certain localities, ordinary cooking utensils may discolor and become stained. This created a demand for an aluminum alloy which would remain bright and attractive in ordinary use. To meet this requirement, two products, Alcoa No. 1 and No. 2 cooking utensil sheet, have been developed and are being evaluated in cookware sets for home use. Various locations were selected to provide a wide variety of foods, cooking customs and types of water. Test results indicate these new alloys have a high resistance to staining. When utensils made from them are anodically coated, they maintain their original appearance and are easy to clean.

Electrical Conductors – A new high-strength alloy, particularly useful in bus work, has been available for several years. Known as No. 2 EC, it is of the aluminum-magnesium silicide type of heat treatable aluminum alloy; it gives high electrical conductivity and strength. Recently, a previously developed alloy of the aluminum-magnesium type, 5005, has been used to secure higher strength in the electrical conductor field.

Porcelain Base – Three new aluminum products developed specifically for the application of porcelain enamel finishes are now available. These are identified as No. 1 porcelain enameling sheet and No. 1 and No. 2 porcelain enameling extruded shapes. Their use assures uniform behavior of the metal throughout the enameling process. Less critical control is needed in conditioning the metal surface and better adherence of the enamel is obtained. These result in lower cost for applying porcelain coatings to aluminum and also give a better quality finish.

What's New in Everyday Uses for Metals

Stainless Steels

*By RICHARD E. PARET**

THE MERITS of Types 201 and 202, the most recent additions to the list of 37 A.I.S.I. standard stainless steel grades, are becoming well established. Recently, these high-manganese low-nickel grades have been made available in a full range of mill forms. An indication of the increased interest in Type 200 stainless is the marked rise in production (to 25,000 tons) for 1957, most of which has been Type 202. Originally developed to conserve nickel during the Korean period, this grade has established itself as a fully qualified member of the stainless steel family.

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Type 202 has slightly greater hardness, tensile strength and ductility than 302 in the annealed condition. Its impact strength is lower than 302 and it provides slightly less resistance to corrosion. But in both these latter two properties 202 rates quite high and can, in most cases, be safely used to replace Type 302. The yield strength of Type 202, however, is about 35% higher than that of 302. This means that lighter gages can frequently be used in specific applications to give lower material costs.

Type 430 – Technological advances have improved the properties of this straight chromium grade. The appearance of stretcher strains in severely drawn parts has virtually been eliminated by modifications of mill annealing practices. In addition, cold forming behavior is more consistent.

Hardenable Chromium-Nickel Grades – Until recently, the combination of high strength and corrosion resistance in chromium-nickel steels could be obtained only by cold working. The new hardenable grades provide both these valuable properties with comparatively simple heat treatment at modest temperatures. Thus, you

can form these hardenable steels and then heat treat them without danger of warpage.

These hardenable steels are helping to extend the applications for stainless. Generally, they show uniform properties in the longitudinal and transverse directions in tension and compression. Various types are available in sheets, plates, bars, rods, forgings, strip and wire.

Extrusion – This has developed into a standard mill-production technique. It offers new economy for stainless steel forms. Extruded shapes are now available in a wide variety of solid and hollow shapes and limitations on tolerance for corners, fillets, and angles are constantly being reduced. Commensurate improvements have been attained for surface finishes, as well as an increase in the maximum cross-sectional area and length (or weight) of extruded shapes.

Flow Turning – This recently developed process enables circular, conical, or parabolic parts to be produced by cold flowing stainless steel over a mandrel. Improvements in blank development, as well as advanced methods for properly balancing pressures and feeds have resulted in better production tolerance control (generally ± 0.002 in.).

Slag Washing – A new pouring technique, known as "slag washing", produces steel free from harmful stringer-type inclusions or banding. First used in producing Type 321 to control segregation of titanium, slag washing can be extended to all grades. Type 321 (a titanium bearing stainless) in some instances has the disadvantage of showing minor surface defects in the highly polished condition. This process makes it possible to develop a full polish on this alloy.

Basically, the cleansing action is accomplished by pouring the steel through a blanket of high-temperature slag placed in the ingot mold prior to teeming. Harmful contaminants are picked up by the washing action. As the molten steel rises in the mold, the slag further serves to provide a protective covering against oxidation. The rate of solidification is also retarded by the slag, which allows the remaining contaminants to float to the top for removal.

Sandwich Rolled Stainless – A significant advance in mill rolling came about this year with the development of a new process which makes available the widest thin-gage stainless steel sheets ever produced. Accomplished by sandwich rolling of stainless steel between two carbon steel cover plates, the process offers many advantages. The procedure has demonstrated the feasibility of producing stainless sheets up to 120 in. wide – more than twice the width of light-gage sheets rolled by conventional methods.

This Dairy Processing Tank is Fabricated From Type 202 Chromium-Manganese Stainless Steel. This grade is harder and has higher yield strength than its 18-8 counterpart. (Courtesy Cherry-Burrell Corp.)

This size sheet eliminates many seams and joints necessary in the fabrication of large parts from narrower sheets. This also means faster production, less weight and reduced waste. Rolling can be done with power provided by existing mills, since assemblies have working characteristics of the carbon steel cover plates. Experiments to determine the best sandwich design and assembly method are now underway to increase the size of the prototypes produced so far.

Decorative Stainless – The increased use of stainless steel in decorative applications has led to the development of new coloring processes and textures. Black stainless steel is being used on architectural and decorative parts. Work is progressing on other colors and some are expected to be available by the end of the year.

Colorful porcelain enamel coatings can be applied continuously or discontinuously on stainless steel sheets. Such sheets are finding more architectural applications in interior and exterior use. Textured stainless steels in a variety of new patterns are continuing to be specified for many product and architectural designs.

Ferrous Castings

*By THOMAS E. EAGAN**

WITH THE EXCEPTION of ductile iron and some new types of malleable iron, the compositions and properties of the ferrous metals used for castings have been known for many years. Emphasis today is on methods to produce better castings at lower cost. Improvements in foundry practices are getting a lot of attention. Many foundries (including the nonferrous ones) are using the newer molding processes, such as investment casting, shell molding, the CO_2 process, and cold set, to improve appearance and quality of castings. These processes may not necessarily reduce the cost of the casting, *per se*, but they produce parts which, because of trueness to size and improved surface, require less costly subsequent treatments.

Gray Iron – Designers are realizing that gray iron covers a vast field of materials, each having engineering qualities which can be used to advantage. Excellent wear resistance, high dampening capacity, lower modulus of elasticity and good castability – all can be used advantageously. Demands for higher quality castings have required an increase in metallurgical controls to parallel the introduction of better melting facilities. Control over raw materials, the use of inoculants, and a more efficient use of alloys are now commonplace, where a few years ago they were only applied by a few foundries. Water cooled cupolas, some using a preheated air blast, are coming into the picture. Some foundries have installed electric furnaces to duplex the iron produced.

Nodular Iron – Since its introduction in 1949, the tonnage of castings made has more than doubled each year until now an impressive tonnage is produced. Several new foundries have been started, or are being started, which will cast only nodular iron. It has been proved that the most economical way to melt for the nodular process is the basic method in contrast with acid practice. Sulphur, which is a rather serious contaminant, can best be controlled by the basic process. The addition of small amounts of misch metal (about 50% cerium) to the ladle overcomes the deleterious effects of elements such as tin, lead, antimony, copper and titanium. This is used as insurance that the graphite will be in the nodular or spherulitic form. The introduction of magnesium under pressure is being used in Europe but it needs considerably more refinement before it can be applied to operations in this country. This type of inoculation should be cheaper; it uses the magnesium somewhat more efficiently and eliminates many of the undesirable features of adding it as an alloy of iron, silicon, and nickel.

Specifications – The great interest in nodular iron is indicated by the fact that there are now three A.S.T.M. specifications for the material: Specification A 339, for general use, calls for one grade with 80,000 psi. tensile strength, 60,000 psi. yield strength and 3% elongation. The other grade requires 60,000 psi. tensile strength, 45,000 psi. yield strength and 10% elongation. Specification A 395 covers metal when used for boiler-code conditions. It is somewhat more restrictive, requiring 60,000 psi. tensile strength, 45,000 psi. yield strength and 15% elongation.

Specification A 396 covers the higher strength materials obtained by either liquid quenching or by normalizing and tempering. One grade requires 120,000 psi. tensile strength, 90,000 psi. yield strength and 2% elongation. These properties are obtained by liquid quenching and tempering. The other grade requires 100,000 psi. tensile strength, 70,000 psi. yield strength and 3% elongation. These properties are obtained by normalizing and tempering. All the tensile properties given above are minimum values. The A.S.M.E. Boiler Code has recently permitted nodular iron to be used at a maximum temperature of 650° F. and a maximum pressure of 1000 psi.

The unique properties of nodular iron, such as excellent machinability, good castability, a favorable range of mechanical properties (with no restrictions on size, weight or section thickness), are making it popular in many applications. We find it being used for such things as gears, valve parts, forming dies and hydraulic cylinders of all sizes and weights.

Malleable Iron – Advances here have, for the most part, been in improved molding and melting practices. Production from malleable foundries usually consists of rather large quantities of parts of one pattern. This fits in well with the newer

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Small Nodular Iron Castings Made to Conform to A.S.T.M. Specification A 339, Grade 60-45-10

molding techniques, such as shell molding, and is favorable for mechanization of molding operations. Melting practice has been improved by the use of cupola-air furnace duplexing. Annealing practices have been improved to give shorter cycles. The use of small quantities of boron and bismuth has increased the thickness of section that can be cast white – a main requirement for good malleable iron.

The use of pearlitic malleable is increasing because of improved annealing techniques to give needed properties. A number of crankshafts, most of which are used in trucks, are now made of pearlitic malleable. One automobile manufacturer is using it for crankshafts in a current model. Pearlitic malleable has better machinability than forgings at the same hardness level.

Pearlitic malleable is more or less in competition with nodular iron – its greatest handicap being that section thicknesses are limited. One malleable foundry has patented a new analysis containing high sulphur which on subsequent annealing gives graphite in spherulitic form instead of the usual temper carbon. The claim is made that heavier sections can be handled with this analysis than normally considered practical.

Steel Castings – These are also being produced by the newer molding techniques. Under the direction of the Steel Founders' Society, steps are being taken to formulate specifications for the raw materials used. This will permit closer quality control on castings. Three such specifications have now been issued and two or three additional ones are being worked up for issuance later this year.

Much needed information on tolerances of castings is being collected, which will result in realistic tolerance values and will eliminate some of the impossible tolerances now called for. Considerable work is being done to study the proper design of castings. Photo-elastic studies and destructive testing by fatigue and tension testing of L and box sections have shown the importance of ample radiuses of joining sections. A film on photo-elastic research prepared by Case Institute of Technology is available from Steel Founders' Society, Cleveland. Research at M.I.T. has shown that solidification segregation and stress concentration results when joining sections of various sizes together with certain radiuses. Such conditions lead to hot tears in the casting. Design rules have been prepared to assist in selecting the proper radiuses in joining section members.

Alloy steel castings with tensile strength of 150,000 to 250,000 psi. are being produced for aircraft and mining applications. Nuclear power uses are employing steel castings for operation at 1000 to 1200° F. under high pressure. Better quality standards for valves, flanges, and fittings and other pipe components have been established. Standards, along with reference photographs, for magnetic powder inspection have been formulated.

Steels . . . Alloy and Carbon

*By E. W. HUSEMANN**

THE SEARCH for cheaper alloy steels has continued; several new grades have been developed for gears, pinions and some automotive shafts. Three new molybdenum steels (A.I.S.I. 4422, 4427, 4520) and one chromium-nickel-molybdenum type (A.I.S.I. 4718) have entered this picture. A chromium-vanadium steel (A.I.S.I. 6118) for automotive shafts and steering gear parts and a straight chromium grade (A.I.S.I. 5115) for piston pin applications have been added as standard steels. Producers have been making these two grades for some time. The composition of these new steels is shown in the Data Sheet, page 120-B, which gives standard alloys based on the revised list released by A.I.S.I. late in July.

Fewer Alloys – The A.I.S.I.'s list of standard alloy steels published last year (*Metal Progress* Data Sheet, August 1957) contained substantially fewer alloys than the previous list released in 1955. Steels such as the 2300, 2500 and some of the 3100 grades were dropped from the 1957 list because users had trouble getting them during the nickel shortage. They turned to other alloys and increased the carbon content to get the hardenability required. For example, a new alloy with no nickel, 4012, replaced 4608 for bearing applications. Alloy 8822 (used for pinions and gears) was added as an alternate to some of the 4800 steels. Some of the 8700's were taken out because it had been found that 8600's could be used in some applications to advantage and they are cheaper.

The 1958 A.I.S.I. list covered in the Data Sheet in this issue of *Metal Progress* shows a further curtailment in the 3100 grades with dropping of alloy 3135. Also, two standard and one tentative standard boron grades were eliminated. Users are turning to boron grades with higher carbon to get improved physical properties which are needed for today's more powerful engines. Grade 9314 was taken off the new list; it was little used because 9310 was preferred in most applications.

Triple - Alloy Grades – Nickel-chromium-molybdenum steels, usually called triple-alloy or three-way alloy grades, may offer economy in use over cheaper single alloy compositions. Producers generally prefer to make these grades – 4300, 4700, 8600, and 8700 types – because they can make more general use of scrap. The user may find that in a single alloy steel the residual nickel, chromium or molybdenum may vary from heat to heat. Potential difficulties include variations in hardenability and annealing and distortion trouble. The extra cost of a composition in which nickel, chromium and molybdenum are controlled may be repaid several times by more uniform heat treating results.

Actually the combination of nickel, chromium and molybdenum is good because the elements complement each other to give toughness and ductility, hardness and depth of hardenability to the heat treated part. This applies to steels in both the carburizing and oil hardening ranges. The triple-alloy grades are excellent all-purpose steels and the selection of the proper grade should be made with design and use in mind.

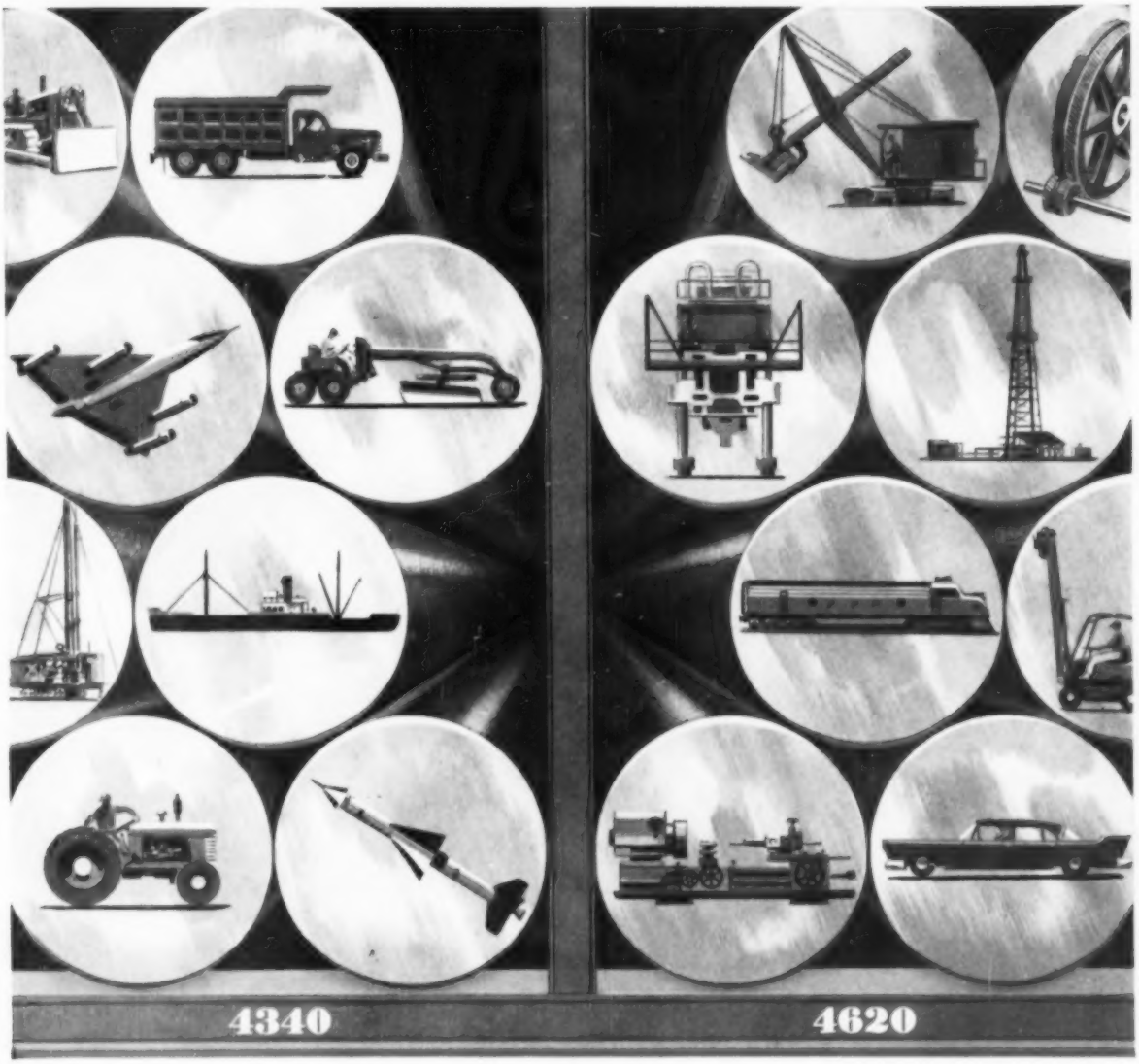
Boron Grades give mechanical properties after heat treating which are equivalent in many instances to steels with higher alloy content. Boron is used most frequently in the 0.30 to 0.70% carbon range. Grades 94 B 30 and 94 B 40 are used for spindles. Grade 51 B 60 is used for various spring applications. Boron also improves the hardenability of bolting stock and fasteners.

Carburizing Grades – Alloy steels continue to be important here. A.I.S.I. types include grades with small amounts of alloying elements, those with intermediate amounts, and grades with quite large amounts. Examples are: 4023 and 5015 for the low; 3120, 4118, 5120, 6120, 8620, and 8720 for the intermediate; and 2317, 2515, 4320, and 9310 for the high-alloy grades.

Applications are for pins, bushings, gears, bearings, pinions and similar parts. Stress and unit loads determine the grade to be selected with the more highly alloyed grades being used to carry heavier loads.

The carbon grades 1016, 1018, 1019, 1021 and 1022 are popular for carburizing applications at lower stress levels where alloy steels are not required. For carbo-nitriding, these grades plus 1118, 1119, 1211, 1212 and 1213 are used.

*Chief Metallurgist, Copperweld Steel Co., Warren, Ohio.



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INCO TRADE MARK

A.I.S.I. Standard Alloy Steel Compositions[a]

A.I.S.I. List as of July 1958

Openhearth and Electric Furnace Alloy Steels

(Bars, billets, blooms and slabs up to 200 sq. in., 18 in. wide or 10,000 lb.)

A.I.S.I. Number [b]	C	Mn	Ni	Cr	Mo
1330	0.28-0.33	1.60-1.90	.....	.....	.....
1335	0.33-0.38	1.60-1.90	.....	.....	.....
1340	0.38-0.43	1.60-1.90	.....	.....	.....
1345	0.43-0.48	1.60-1.90	.....	.....	.....
TS14B35 [e]	0.33-0.38	0.75-1.00	.....	.....	.....
3140	0.38-0.43	0.70-0.90	1.10-1.40	0.55-0.75	.....
E3310 [c]	0.08-0.13	0.45-0.60	3.25-3.75	1.40-1.75	.....
4012	0.09-0.14	0.75-1.00	.....	.....	0.15-0.25
4023	0.20-0.25	0.70-0.90	.....	.....	0.20-0.30
4024 [d]	0.20-0.25	0.70-0.90	.....	.....	0.20-0.30
4027	0.25-0.30	0.70-0.90	.....	.....	0.20-0.30
4028 [d]	0.25-0.30	0.70-0.90	.....	.....	0.20-0.30
4037	0.35-0.40	0.70-0.90	.....	.....	0.20-0.30
4042	0.40-0.45	0.70-0.90	.....	.....	0.20-0.30
4047	0.45-0.50	0.70-0.90	.....	.....	0.20-0.30
4063	0.60-0.67	0.75-1.00	.....	.....	0.20-0.30
4118	0.18-0.23	0.70-0.90	.....	0.40-0.60	0.08-0.15
4130	0.28-0.33	0.40-0.60	.....	0.80-1.10	0.15-0.25
4135	0.33-0.38	0.70-0.90	.....	0.80-1.10	0.15-0.25
4137	0.35-0.40	0.70-0.90	.....	0.80-1.10	0.15-0.25
4140	0.38-0.43	0.75-1.00	.....	0.80-1.10	0.15-0.25
TS4140	0.38-0.43	0.80-1.05	.....	0.90-1.20	0.08-0.15
4142	0.40-0.45	0.75-1.00	.....	0.80-1.10	0.15-0.25
4145	0.43-0.48	0.75-1.00	.....	0.80-1.10	0.15-0.25
4147	0.45-0.50	0.75-1.00	.....	0.80-1.10	0.15-0.25
4150	0.48-0.53	0.75-1.00	.....	0.80-1.10	0.15-0.25
TS4150	0.48-0.53	0.80-1.05	.....	0.90-1.20	0.08-0.15
4320	0.17-0.22	0.45-0.65	1.65-2.00	0.40-0.60	0.20-0.30
4337	0.35-0.40	0.60-0.80	1.65-2.00	0.70-0.90	0.20-0.30
E4337	0.35-0.40	0.65-0.85	1.65-2.00	0.70-0.90	0.20-0.30
4340	0.38-0.43	0.60-0.80	1.65-2.00	0.70-0.90	0.20-0.30
E4340	0.38-0.43	0.65-0.85	1.65-2.00	0.70-0.90	0.20-0.30
4422	0.20-0.25	0.70-0.90	.....	.....	0.35-0.45
4427	0.24-0.29	0.70-0.90	.....	.....	0.35-0.45
4520	0.18-0.23	0.45-0.65	.....	.....	0.45-0.60
4615	0.13-0.18	0.45-0.65	1.65-2.00	.....	0.20-0.30
4617	0.15-0.20	0.45-0.65	1.65-2.00	.....	0.20-0.30
4620	0.17-0.22	0.45-0.65	1.65-2.00	.....	0.20-0.30
4621	0.18-0.23	0.70-0.90	1.65-2.00	.....	0.20-0.30
4718	0.16-0.21	0.70-0.90	0.90-1.20	0.35-0.55	0.30-0.40
4720	0.17-0.22	0.50-0.70	0.90-1.20	0.35-0.55	0.15-0.25
4815	0.13-0.18	0.40-0.60	3.25-3.75	.....	0.20-0.30
4817	0.15-0.20	0.40-0.60	3.25-3.75	.....	0.20-0.30
4820	0.18-0.23	0.50-0.70	3.25-3.75	.....	0.20-0.30
5015	0.12-0.17	0.30-0.50	.....	0.30-0.50	.....
5046	0.43-0.50	0.75-1.00	.....	0.20-0.35	.....
50B40 [e]	0.38-0.43	0.75-1.00	.....	0.40-0.60	.....
50B44 [e]	0.43-0.48	0.75-1.00	.....	0.40-0.60	.....
50B46 [e]	0.43-0.50	0.75-1.00	.....	0.20-0.35	.....
50B50 [e]	0.48-0.53	0.75-1.00	.....	0.40-0.60	.....
50B60 [e]	0.55-0.65	0.75-1.00	.....	0.40-0.60	.....
51B60 [e]	0.55-0.65	0.75-1.00	.....	0.70-0.90	.....

A.I.S.I. Number [b]	C	Mn	Ni	Cr	Mo
5115	0.13-0.18	0.70-0.90	.....	0.70-0.90	.....
5120	0.17-0.22	0.70-0.90	.....	0.70-0.90	.....
5130	0.28-0.33	0.70-0.90	.....	0.80-1.10	.....
5132	0.30-0.35	0.60-0.80	.....	0.75-1.00	.....
5135	0.33-0.38	0.60-0.80	.....	0.80-1.05	.....
5140	0.38-0.43	0.70-0.90	.....	0.70-0.90	.....
5145	0.43-0.48	0.70-0.90	.....	0.70-0.90	.....
5147	0.45-0.52	0.70-0.95	.....	0.85-1.15	.....
5150	0.48-0.53	0.70-0.90	.....	0.70-0.90	.....
5155	0.50-0.60	0.70-0.90	.....	0.70-0.90	.....
5160	0.55-0.65	0.75-1.00	.....	0.70-0.90	.....
E50100	0.95-1.10	0.25-0.45	.....	0.40-0.60	.....
E51100	0.95-1.10	0.25-0.45	.....	0.90-1.15	.....
E52100	0.95-1.10	0.25-0.45	.....	1.30-1.60	.....
6118	0.16-0.21	0.50-0.70	.....	0.50-0.70	0.10-0.15 V
6120	0.17-0.22	0.70-0.90	.....	0.70-0.90	0.10 min. V
6150	0.48-0.53	0.70-0.90	.....	0.80-1.10	0.15 min. V
8115	0.13-0.18	0.70-0.90	0.20-0.40	0.30-0.50	0.08-0.15
81B45 [e]	0.43-0.48	0.75-1.00	0.20-0.40	0.35-0.55	0.08-0.15
8615	0.13-0.18	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8617	0.15-0.20	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8620	0.18-0.23	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8622	0.20-0.25	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8625	0.23-0.28	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8627	0.25-0.30	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8630	0.28-0.33	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25
8637	0.35-0.40	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8640	0.38-0.43	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8642	0.40-0.45	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8645	0.43-0.48	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
86B45 [e]	0.43-0.48	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8650	0.48-0.53	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8655	0.50-0.60	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8660	0.55-0.65	0.75-1.00	0.40-0.70	0.40-0.60	0.15-0.25
8720	0.18-0.23	0.70-0.90	0.40-0.70	0.40-0.60	0.20-0.30
8735	0.33-0.38	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8740	0.38-0.43	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8742	0.40-0.45	0.75-1.00	0.40-0.70	0.40-0.60	0.20-0.30
8822	0.20-0.25	0.75-1.00	0.40-0.70	0.40-0.60	0.30-0.40
9255 [f]	0.50-0.60	0.70-0.95	.....	.....	.....
9260 [f]	0.55-0.65	0.70-1.00	.....	.....	.....
9262 [f]	0.55-0.65	0.75-1.00	.....	0.25-0.40	.....
E9310	0.08-0.13	0.45-0.65	3.00-3.50	1.00-1.40	0.08-0.15
94B15 [e]	0.13-0.18	0.75-1.00	0.30-0.60	0.30-0.50	0.08-0.15
94B17 [e]	0.15-0.20	0.75-1.00	0.30-0.60	0.30-0.50	0.08-0.15
94B30 [e]	0.28-0.33	0.75-1.00	0.30-0.60	0.30-0.50	0.08-0.15
94B40 [e]	0.38-0.43	0.75-1.00	0.30-0.60	0.30-0.50	0.08-0.15
9840	0.38-0.43	0.70-0.90	0.85-1.15	0.70-0.90	0.20-0.30
9850	0.48-0.53	0.70-0.90	0.85-1.15	0.70-0.90	0.20-0.30
Standard Nitriding Steel [g]					
....	0.38-0.43	0.50-0.70	.....	1.40-1.80	0.30-0.40

NOTE *(a)* — All chemical ranges and limits are subject to the standard variations for check analysis over or under specification.

NOTE *(b)* — Numbers with prefix **E** are generally made in basic electric furnaces and unless otherwise noted the following specifications hold: phosphorus 0.025% max., sulphur 0.025% max., silicon 0.20 to 0.35%.

Numbers without letter prefix are ordinarily made in basic openhearth furnaces and unless otherwise noted the following specifications hold: phosphorus 0.040% max., sulphur 0.040% max., silicon 0.20 to 0.35%.

Specification limits for the acid electric and acid openhearth processes are: phosphorus 0.050% max., sulphur 0.050% max., silicon 0.15 to 0.35%.

In all processes the maximum allowable quantities of unspecified and incidental elements are as follows: 0.35% copper, 0.25% nickel, 0.20% chromium and 0.06% molybdenum.

Numbers with prefix TS represent tentative standard steels.

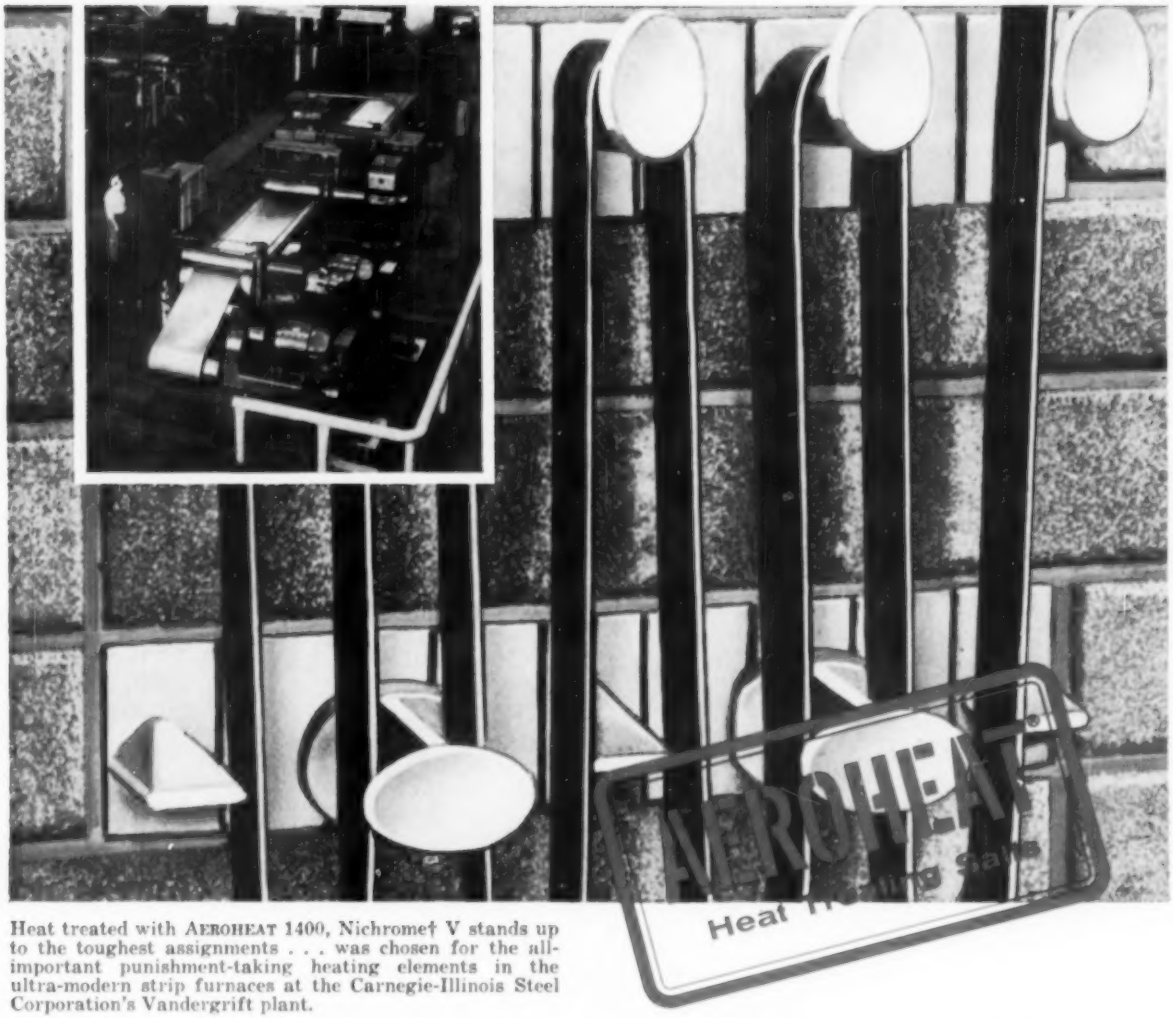
NOTE *(c)* — When this steel is made in openhearth furnaces the manganese is 0.45 to 0.60%.

NOTE *(d)* — Resulphurized steels; sulphur is 0.035 to 0.050%.

NOTE *(e)* — This steel can be expected to have 0.0005% min. boron.

NOTE *(f)* — Silico-manganese steels; silicon range is 1.80 to 2.20%.

NOTE *(g)* — The standard nitriding steel has silicon 0.20-0.40 and aluminum 0.95-1.30.



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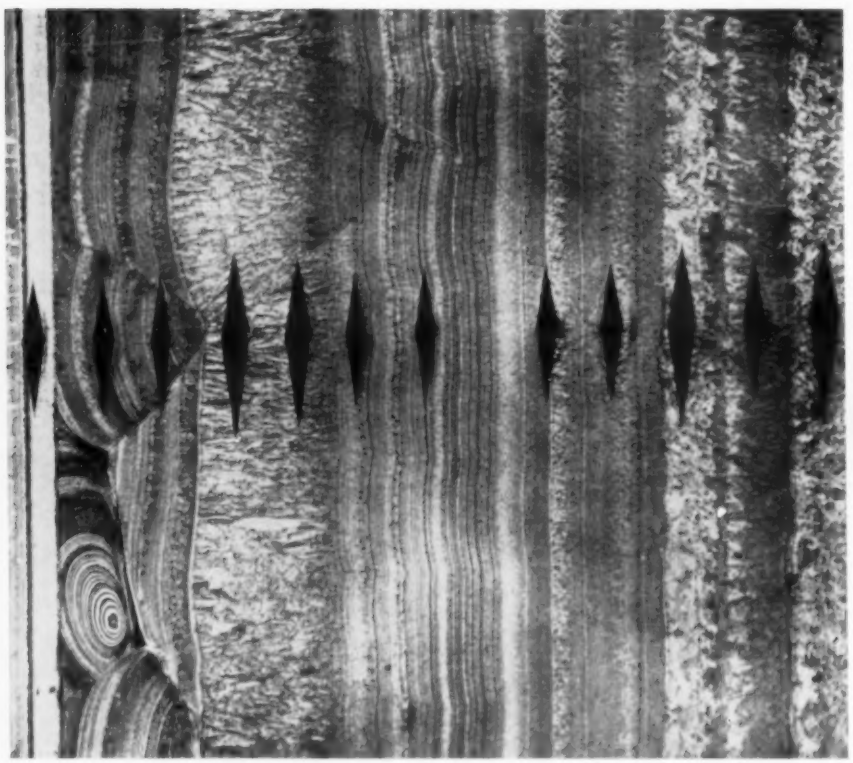

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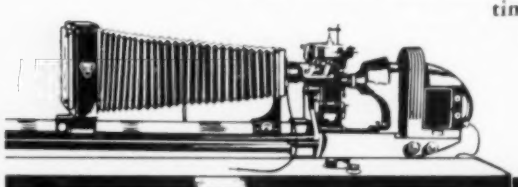

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Nitriding – This process develops a case hardened skin which has excellent resistance to wear and good antigalling properties. Nitriding is used with heat treated bars because any free ferrite causes brittleness and spalling. Steels containing appreciable amounts of aluminum overcame these difficulties, which led to the development of the Nitralloy analyses. For many years the nitriding process has been used with these grades, and a standard composition was given for the first time in the A.I.S.I.'s 1957 list.

Recent work has shown that both 4140 and 4340, heat treated prior to nitriding (a processing step similar to that used with the regular Nitralloy grades), give excellent results. We feel there will be more activity in this direction.

Induction Hardening – This method of heat treatment is making it possible to change from alloy to lower cost carbon steels in some applications. One example is automotive axles. A part can be considered for this change where the stress pattern is such that the shallow pattern typical of carbon steels is adequate. Induction hardening is readily incorporated into mechanized operations; in one instance, it's done as one stage of an automatic screw machine operation.

Leaded Steels – Outstanding property of leaded steels is improved machinability. Enough lead is added to meet the range of 0.15 to 0.35%. Lead lubricates the cutting action of the tool – allows heavier cuts and faster speeds. Longer tool life comes from lower temperature at the tool-part interface. Better surface finish is obtained. In some instances, a roughing out may give the surface needed without a final finishing operation.

It is now fairly well established that lead has little effect on the tensile properties of alloy steels apart from a slight loss of ductility and perhaps impact strength. These are not serious enough to be of concern. Hardenability is equivalent. Leaded steels may be treated in the same manner as their non-leaded counterparts if certain precautions in cutting and welding are recognized and allowed for.

Leaded grades do not require modifications in forging practice. Forged parts have the same machinability as those made from leaded steel bars. Gear cutting, milling, drilling, boring, threading, go faster on leaded grades. A carbon grade leaded plate is finding use in applications where extensive machining or drilling is needed. Leaded bar and wire grades, such as 1010 and 1018, are coming into use in operations where cold heading is combined with machining. Here it has been found that leaded steels have better flowability than resulphurized grades.

Practically all standard A.I.S.I. carbon and constructional alloy steels are available in leaded grades. Carburizing steels referred to above are used in leaded grades where machinability is a factor. Most leaded steel bars for making machined parts are purchased in the cold finished condition.

Cold Forming – Developments in cold extrusion and cold heading processes are making it possible for manufacturers to use bar stock to form a variety of parts. Pins, bushings, bearing cups, spark plug shells, fasteners, and gears of various types are extruded and machined as required to form the finished part. Advantages include such things as less machining, better mechanical properties (which may eliminate a heat treating operation), more efficient use of materials (less scrap), better finish and elimination of intermediate operations.

Interior Trim Parts of 1958 Automobiles Made of 22-Gage, Cold Rolled Steel Sheets to Which Has Been Bonded a Layer of Vinyl Plastic. The auto parts are shown on a folding table which also has a vinyl-clad top. (Courtesy Jones & Laughlin Steel Corp.)

Usually round bar stock of low-carbon aluminum-killed steel is used. The smaller parts may be made by an upsetting or sizing operation followed by annealing, phosphate coating and a single cold extrusion. Larger parts may require multiple extrusion stages, using intermediate anneals, because of work hardening of the piece. Increased metallurgical know-how is making it possible to use steels with higher carbon content or with more alloy than was thought possible in the past.

Advances in lubricants for cold heading are expanding the potential of this process. One trend is toward larger parts – fasteners for example – so that one large fastener can do the job which formerly required several smaller ones. Higher carbon steels, such as 1040 and 1041, are being used to realize improved hardenability for higher strength. So-called "warm heading" is expected to open up new applications, and satisfactory lubricants are becoming available for this process.

High-Strength Steels – Today, more than ever before, attention is focused on metals with better strength-to-weight ratios to make products smaller, lighter and stronger. A special group of steels is tailored to a variety of tonnage applications where a relatively inexpensive, high-strength, easily fabricated metal is needed. This family of steels, known as high-strength low-alloy steels, comprises more than 20 proprietary compositions. Their strength (as measured by yield point) is some 50% higher than that of structural carbon grades. Generally, they are furnished in the as-rolled condition to minimum yield point of 50,000 psi. in thicknesses up to about ½ in. Their resistance to abrasion and corrosion is good. Although they cost more than carbon grades, they are paying their way in a diversity of products. Steels are also available at several higher intermediate-strength levels. For example, a quenched and tempered low-alloy steel is produced to a minimum yield strength of 90,000 psi. Its combination of high strength and toughness adapts it to many heavy-duty uses.

Super Strength Steels – A group of low-alloy hardenable engineering steels are being used where ultra high strength is needed. Parts made from 4340 and similar alloy types have been heat treated to 260,000 to 280,000 psi. and some compositions have reached the 325,000-psi. level. Ductility at these strength levels is necessary, particularly in the transverse direction. This mechanical property requirement is expected to go higher. It appears that such factors as non-metallic inclusions and percentage reduction from the ingot have an appreciable effect on the mechanical properties.

Formability* – Modern styling of automotive and many other products is making increased metallurgical demands on hot and cold rolled steels. The selection of the proper type of sheet steel to produce the needed part under most economical conditions is an important consideration to users. With cold rolled sheets, there are three principal qualities available: commercial quality, drawing quality rimmed and drawing quality killed. If the part involves simple bending, moderate forming, or only slight stretching, commercial quality is a good selection. This assumes that part design and die practice will accommodate material approaching maximum hardness of Rockwell B-60. If light stretching is applied to a part which must be free of surface disturbances, known as stretcher strains, commercial quality should not be considered unless an efficient roller leveler is employed immediately before stamping. Also the metal should be fabricated within a reasonably short time after it arrives in the plant.

For parts requiring a significant degree of stretching and drawing, the proper quality should be drawing quality rimmed. If the part must be free of stretcher strains, efficient roller leveling should be used immediately before stamping, and fabrication should be done within a reasonably short time after steel is received. For parts of a critical drawing nature, or those which must be free of stretcher strains after drawing, material specified should be drawing quality killed. This is particularly true if no roller leveling is to be used or if an appreciable time lag is expected between receipt of steel and its fabrication into parts.

Hot Finished Grades – Hot rolled or hot rolled pickled sheets may be specified in the same three qualities with forming properties improved at each quality level. However, these two grades do not possess drawing properties equivalent to cold rolled sheet and caution must be exercised when considering them for parts with drawn or severely stretched areas, particularly in the lighter gages.

Deciding on the most suitable quality for

*This section adapted from information supplied by Charles Buker, Supervisor, Product Technical Services, Jones & Laughlin Steel Corp. The author also acknowledges assistance from American Steel & Wire Div. of U.S. Steel Corp., Bethlehem Steel Co., and Republic Steel Corp. in various sections of this report.

either cold rolled or hot rolled sheets is not always simple, because often times the decision must be made using a blueprint or model of the finished part. It's usually most economical to specify the quality which will assure satisfactory performance and then try to use lesser qualities after actual die experience has been gained. (Helpful suggestions on determining quality requirements are given in an article prepared by an ASM Committee on Formability of Sheet Steel, published in *Metal Progress*, Aug. 15, 1955, as a supplement to the ASM Metals Handbook.)

Keep Finish in Mind – Users are finding that in many instances they can economize on a final product by selecting a material with a finish tailored as closely as possible to their final needs. Even though the material may cost more, savings come from elimination of extra steps in fabricating and finishing. A number of new areas are opening up in embossed and pre-finished steels. A bright-finished aluminum-coated steel wire will be available in the near future offering decorative and corrosion resistant properties.

Cold rolled steel sheets, clad with a layer of vinyl plastic, offer new possibilities in decorative applications. Parts produced from this composite material are being used in 1958 automobiles and it's expected to find numerous other uses such as in appliances, furniture and other home applications. It combines the strength of steel with the chemical resistance of vinyl and is cigarette-burn proof, stainproof and scratchproof. Parts may be formed by shearing, punching, drilling, brake press beinding, roll forming and cold drawing without affecting the bond between the vinyl coating and the steel.

What's New in Everyday Uses for Metals

Copper . . . Wrought Alloys

*By ARTHUR I. HEIM**

THE LIST of standard commercial wrought copper and copper-base alloys, issued by Copper and Brass Research Assoc. in January this year (in revised form), contains 42 alloys which are standard in the sense that over a period of years they have been the alloys most commonly ordered by users in large quantities. Alloys range from commercially pure coppers to those categorized generally as nonleaded brasses, leaded brasses, tin and aluminum brasses, phosphor bronzes, cupronickel and nickel silvers and silicon bronzes. In addition to these, many special and proprietary alloys are available for various uses, including aluminum bronzes, cadmium bronzes, beryllium coppers, aluminum-tin bronzes, and copper-chromium alloys.

Among the copper-base alloys are those with excellent machinability; most of the alloys also offer superior fabricating characteristics. Other useful properties include high electrical and thermal conductivity, good corrosion resistance and low magnetic permeability. They have a broad range of attractive colors: the red of copper, the yellow of brass and the silvery-white of the nickel-silver copper alloys, for example.

Fine-Grain Phosphor Bronze – The performance of fine-grain phosphor bronze spring wire shows up well in the report of a consulting engineering firm which had tested it on a Comaco Elasticometer precision testing instrument. Stresses were as follows:

Stress at initial installed position – 36,600 psi.
Stress at final deflected position – 73,200 psi.
Stress range during deflection – 36,600 psi.

Results showed that the springs were still satisfactory with no appreciable loss of load after 2,000,000 deflections and demonstrated that high endurance and long fatigue life at high stresses can be expected from springs made of this fine-grain phosphor bronze.

Better Formability – A relatively new, fine-grain drawing brass has proven a boon to manufacturers because in many instances it eliminates certain finishing operations. One user, for example, reports savings up to 40% on polishing such deep drawn products as pens, pencils, lipstick cases and miniature flashlight cases. Another, a maker of solid brass lighting fixtures, was plagued with a bottleneck in his polishing room until he turned to fine-grained brass. The bot-

*Research Engineer, Copper and Brass Research Assoc., New York.

These Segmented Brass Gears Are Produced for Use in Fire Alarm Boxes for Sounding Distinctive Coding Signals. (Courtesy Edwards Co., Norwalk, Conn.)

tleneck was eliminated and polishing cost savings on various items ran 62, 45, 48 and 55%.

An entirely new concept in a phosphor bronze strip product has emerged: a spring temper, phosphor bronze with increased ductility of 200% or more. It is available in three grades. The new metal promises better formability, greater part uniformity and less tool wear, yet it retains all the strength and hardness of regular spring temper bronze. These advantages, along with a suitability for more intricate parts, give this copper alloy added appeal for tool designers.

Special continuous casting techniques are producing phosphor bronze bridge plates free from blowholes, porosity, and cracks. The bridge plates are cold rolled to a required size. Phosphor bronze is preferred for the plates because of its resistance to corrosion and its low coefficient of friction. Also, it has good resistance to abrasion and wear.

Nickel-Silicon Bronze – This corrosion resistant alloy has high yield strength and high ultimate tensile strength, even at elevated temperatures. Consisting of 97.5% Cu, 1.9% Ni and 0.6% Si, it is age hardenable and is available in soft, intermediate, and hard tempers. Age hardening of the alloy is carried out at 900° F. for 90 min. The new alloy is available in a variety of cross sections and dimensions, in straight lengths of rod and bar, and coils of round, rectangular, and square rolled and drawn wire.

Stress-corrosion cracking has been dealt a blow by a new aluminum bronze alloy. The alloy eliminates the need to stress-relieve all finished fabrications as a precaution against stress-corrosion cracking. It also permits alterations or repairs in the field without heat treatment. The new alloy should be useful for equipment in chemical processing, petro-chemical, petroleum, distillation and others where applications have been confined to nickel bearing and stainless steel alloys.

Embossed Designs – A variety of art metal for designers is available in a wide selection of patterns cold rolled on copper, brass, bronze and some of the nickel silvers. New and exclusive designs can be produced on special order. The product is supplied in flat strips or rolls, and in soft annealed or commercially hard tempers.

Swimming Pools – The backyard swimming pool makes an important use of copper in its heating apparatus. One gas-fired, instant heat boiler has a combustion chamber formed of copper sheet. The water for heating is circulated around the chamber through ⅝-in. soft copper tube brazed to the sheet and into a fin-and-tube copper coil at the top. Copper's resistance to corrosion and excellent thermal conductivity make it especially useful for this application.

What's New in Everyday Uses for Metals

Magnesium

*By C. E. NELSON**

FOLLOWING the trend of older metals, magnesium is becoming more of a mill product material. A recent development is precision shaved extrusions. An extruded magnesium part (at room temperature) is pulled through a die, slightly smaller than the extrusion, which is equipped with sharp cutting edges. Metal is shaved from the surface to give an extrusion with close tolerance and good surface finish.

A new magnesium alloy, designated K 1 X 1, has exceptionally high damping capacity. Bell Telephone Laboratories has led in the development of uses for it which are expected to include missile and aircraft electronic equipment. Work to develop improved fasteners for magnesium is in progress. Purpose is to reduce galvanic corrosion and to produce fasteners suitable for elevated-temperature use. Magnesium tooling plate is now being produced in closer flatness tolerances permitting a one-third reduction in the guaranteed deviation from flatness.

Thin Wall Castings – This technique for magnesium, under development for some years, is now in production use. Sections with small cross-sectional area are being cast as thin as 0.010 in. Even more significant is the production of large castings with relatively thin walls. The air scoop of the Regulus II missile, which is a one-piece, 150-lb. casting in AZ 91 C alloy, has a nominal wall thickness of 0.240 in. Its solid leading edge tapers to a 0.015-in. cast radius. The Regulus II's split clamshell, vertical fin tip, also designed in AZ 91 C alloy, is cast to a thickness of about 0.120 in.

Die Castings – Development of a hot-chamber die-casting process several years ago put magnesium casting rates ahead of aluminum and about even with zinc. Now a new cold-chamber, automatic metering process shows promise of bringing significant cost reductions. This new technique eliminates hand-ladling of metal, and is more economical to install and operate than the hot chamber method. Also it is almost as fast. Production rates up to the cooling capacity of the dies are possible. Peak rates of 700 shots per hr. have been realized with small magnesium parts.

Extrusions – The pellet process is giving stronger extrusions with minimum compressive yield strength up to 35,000 psi. This is as much as 40% higher than most sections extruded from ingots. The higher strength of pellet extrusions is due to the fact that the strength of magnesium wrought section varies inversely with its grain size. The spherical pellets used in these extrusions are about 0.016 in. in diameter and are very fine grained. It's expected that even higher strength sections will be possible by this technique in the future.

Development of solution heat treatment and aging of magnesium forgings from alloy ZK 60 A offers a substantial increase in their tensile yield and creep strengths and a lesser increase in ultimate tensile strength. The treatment (to the T 6 condition) primarily affects large magnesium forgings; properties realized should easily exceed the minimum required by Government specifications. A large aircraft wheel forging, after T 6 treatment, has tensile yield strength of 44,000 psi. and ultimate tensile strength of 48,000, compared to tensile yield strength of 29,000 and ultimate tensile strength of 44,000 with only T 5 (artificial aging) treatment.

Dip Brazing – This process is in production-line use by a manufacturer of wave guides and other components of air-borne radar equipment. Dip brazing is useful when the design involves

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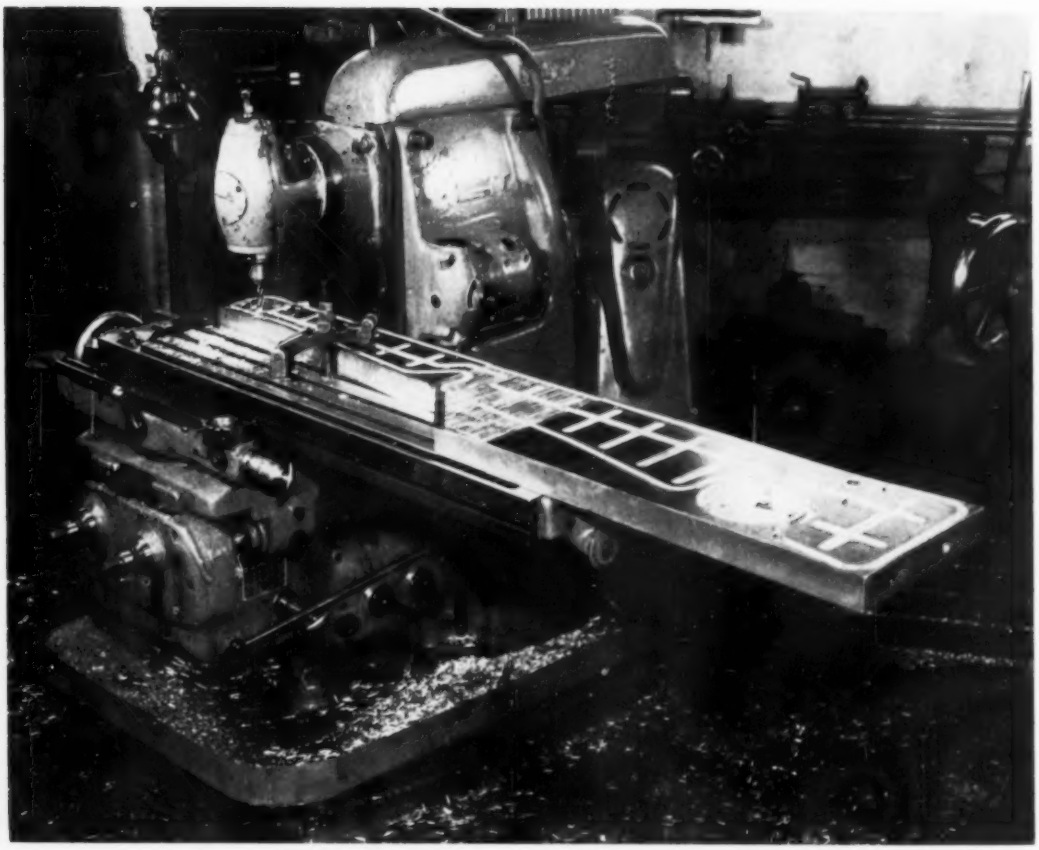

Machining Magnesium Tooling Plate. This product is now being made with closer flatness tolerances

complex joints that are difficult to reach with a welding torch, or where tolerances are so close that shrinkage and warpage associated with fusion welding become a problem. In dip brazing, the parts to be joined are immersed in a molten flux bath having a temperature below the melting point of the parts, but above the melting point of the brazing alloy.

Plating on Magnesium – An electroless nickel plating process is now available for magnesium. Parts are immersed in a special nickel solution and plated without use of electric current. The result: a simpler process than electroplating on magnesium and a better nickel coating. The nickel coating uniformly covers all surfaces, including the inside of drilled holes and other recesses. Zinc immersion plus copper strike (a necessary step in electroplating nickel on magnesium) is used with the electroless process only if maximum corrosion protection is required.

Weight Saving – Magnesium traditionally has been used where light weight and good strength are required. Missile designers are finding that the thickness of a magnesium section can be increased to produce maximum resistance to compression buckling or maximum rigidity without a weight penalty. Significant amounts of magnesium are being used in at least 20 different missiles at this time.

In another military area, ground vehicles, substantial uses for magnesium seem to be developing. The Army's "Mechanical Mule" is basically a platform of magnesium extrusions mounted on sand-cast magnesium wheels. It may be the first of a line of military vehicles using large amounts of magnesium in their structures. Work is now in progress on a prototype magnesium hull for an armored carrier. This experimental vehicle, also, will be equipped with magnesium wheels. These developments stem from the Army's new emphasis on speed and lightness for air transport.

The close tolerances possible with magnesium die castings have led to their use in a precision

recording tape reel. Magnesium's light weight permitted the reel to be designed with extra thickness and rigidity without a weight penalty. The metal's excellent dimensional stability was another factor in its selection. These reels are finished with a new clear Dow 17 anodize.

Weight savings in small parts add up to an appreciable over-all savings when the parts are used in large quantities. A case in point is an electrical connector plug designed for the B-58. An all-magnesium, die-cast shell gave a part which was 26% lighter than the previous design. The magnesium shell also meets rigorous environmental and tolerance requirements.

Portable Equipment – Portable chain saws with a higher horsepower-to-weight ratio than ever before achieved are being produced using a variety of magnesium die castings. Another recent magnesium contribution to the portable tool field is a new air-driven tool, weighing 4 lb. used for fastening steel strapping. One of the latest developments in the office equipment field is a pocket-size tape recorder which uses a magnesium case and magazine, and weighs less than 3 lb.

Materials handling equipment, which must itself be handled, continues to make effective use of magnesium. New items recently put on the market include a yard ramp with a manually operated hydraulic lift to provide the desired elevation. This ramp, which is 30 ft. long, 70 in. wide with a load capacity of 16,000 lb., weighs just 2010 lb. A magnesium ladder manufacturer has added a utility platform and scaffolding to his line. Here magnesium extrusions give a sturdy structure with minimum weight.

What's New in Everyday Uses for Metals

Nonferrous Castings

*By D. L. COLWELL**

ALUMINUM CASTING alloys which give high strength without heat treatment, such as the A.S.T.M. ZG and GM series, are now well established in specifications. Their use, to avoid expense of heat treating, is increasing. The two widely used aluminum casting alloys where heat treating is employed, SG 70 A and SC 51 A, are also undergoing changes to give improved mechanical properties. For high strength properties, it is becoming common to use aluminum of 99.8% minimum purity. With iron content held to a maximum of 0.15 or 0.20% in SG 70 A and SC 51 A type castings, elongations obtained are high; heat treatment can be adjusted to produce a higher yield strength and still give elongations of 5% or more. A military specification for these alloys, allowing 0.20% maximum iron, has been prepared. The A.S.T.M. is working on similar specifications where iron limits may be held to an even lower figure.

One variety of high-purity SG 70 A has appeared containing about 0.25% beryllium which decreases oxidation in the foundry but increases the cost. The properties obtained are about the same as those obtained with the regular high-purity grades.

High-Silicon Alloys – Wide interest is being evidenced in the hypereutectic aluminum-silicon alloys containing 20% silicon or more. These alloys have been known for at least 25 years but interest has been revived, particularly for automotive engine uses, because of improved machinability secured by addition of phosphorus. This has reached the production stage in Europe. These alloys are being considered in this country for use in pistons, brakes and similar parts.

Higher Zinc Content – The commonly used aluminum die-casting alloy, SC 84 A, has, in the past, been limited to 1% zinc content maximum. However, the use of this alloy with 2 or 3% zinc content is rapidly superseding the 1% limit. Mechanical properties of alloys with higher zinc are about the same as those with 1%, but both castability and machinability are tremendously improved. Specifications are being prepared.

The A.S.T.M. has completed action to eliminate alloys SC 64 A and SC 64 C. The former had become obsolete and the latter has been superseded by SC 64 D which specifies a magnesium limit of 0.10% instead of 0.50%. The harmful effects of the higher magnesium content

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Using Zinc Die Castings, C. G. Conn, Ltd., Found It More Economical to Obtain a High-Polish Jewelry Finish on These Clarinet Keys. (Courtesy New Jersey Zinc Co.)

were so serious that it was felt unwise to include it in specifications.

Impact Extrusions – Automotive pistons made by impact extrusion from aluminum-silicon alloy slugs produced by the continuous casting process are now commercially available. They are said to have the advantage of higher strength-to-weight ratio with corresponding beneficial effect on engine performance.

An aluminum die-casting alloy which can be anodized is a new development. Because of the absence of copper and silicon and close control of iron and manganese, good anodizing characteristics are obtained. Castability is not as good as in aluminum-silicon alloys, but some fairly complicated castings have been made.

The question of suitable steels for die-casting dies has always been troublesome. Progress is being made on the use of cast toolsteel inserts which are much less expensive than forged inserts and give similar service life. Pure molybdenum has also been used with improved service life, but at greater expense.

Duplicate Test Bars – Considerable development work to study methods for producing castings with properties equal to those of separately cast test bars is under way. An extensive investigation has been sponsored by the American Foundrymen's Society at Battelle Memorial Institute and a series of experiments has been conducted at Massachusetts Institute of Technology. The Battelle work establishes principles necessary for correct gating and the M.I.T. studies emphasize the importance of rapid and progressive solidification for the improvement of mechanical properties, particularly in certain critical sections.

Zinc-Base Die Castings – Their use in automotive applications is increasing. From 43 lb. used in the average car in 1950, they reached about 65 lb. average in 1957. Improvements in gating are said to give better weathering properties in plated zinc-base die castings. It's also reported that die castings produced in vacuum give an improved surface for plating.

Magnesium Castings – Interest in new magnesium-base alloys with higher mechanical properties is increasing. The EK series, with additions of rare earths and zirconium, the HK alloys containing thorium and zirconium, and the ZH and ZK alloys containing zinc with rare earths and zirconium, respectively, give mechanical properties as high as 35,000 psi. tensile strength and 4% elongation in the sand cast (T 5) condition. Tensile strength is as much as 40,000 psi. with 5% elongation in the sand-cast T 6 and T 7 condition.

In both sand and permanent mold castings, these new magnesium alloys have better properties at high temperatures than the usual magnesium-aluminum-zinc alloys.

New magnesium alloys are being developed for atomic reactor applications and also for superior damping characteristics. These have not yet reached specification stage. While die casting of magnesium has not approached the volume for aluminum alloys, it has been given impetus by the new Dow development where the metal is introduced into the cold chamber by a metering device which accurately measures the amount needed and at the same time protects it from oxidation (also see page 125). With the development of new high-strength alloys and improvements in casting techniques, it's expected that magnesium castings will become more and more important in the production of all kinds of products where light weight and excellent machinability are required.

Cast High Alloys

*BY E. A. SCHOEFER**

THE HIGH-STRENGTH corrosion resistant CD-4MCu alloy has aroused considerable interest since its introduction about a year ago. The new alloy is finding many applications as a replacement for "comparable" 18-8 stainless alloys. It has about double the mechanical strength of the 18-8 grades, while its corrosion resistance is about the same. The outlook for this precipitation hardening alloy is brightest where combinations of severe corrosive conditions and mechanical stress exist. Uses include special valves, pumps, fittings, and high-pressure components. The alloy has the following composition: 25 to 27% Cr; 4.75 to 6.00% Ni; 0.040% max C; 1.75 to 2.25% Mo; 2.75 to 3.25% Cu; 1.00 max. Mn; 1.00% max. Si; 0.04% max. P; 0.04% max. S. When the alloy is precipitation hardened (3 hr. at 850 to 950° F.), typical properties are: hardness, Brinell 300; tensile strength, 140,000 psi.; yield strength, 100,000 psi.

Parts for Atomic Energy – Many of the pumps, valves and fittings being installed in Detroit Edison's Enrico Fermi nuclear power plant and the SPERT-III pressurized water reactor are made of Type CF-4 (extra-low carbon 18-8) alloy. Type CF-8 (0.08% C max.) alloy, however, meets all requirements for use in the primary coolant loops of the pressurized water reactors, and is being increasingly specified. The Shippingport Atomic Power Station uses an 8000-lb. pump casing and 18-in. valve bodies – all cast of Type CF-8 – in each of its four primary coolant loops.

In the Yankee Atomic Electric Co. and Consolidated Edison nuclear power plants, now under construction, 15,000-lb. pump casings have been designed to be cast in Type CF-8 alloy. Capacity of the pumps will be 24,000 gal. per min. These large cast stainless units meet all requirements of the A.S.M.E. Power Boiler and Unfired Pressure Vessel Code.

Highly corrosive rocket fuels are being handled by corrosion resistant castings, and heat resistant castings are being used for components in launching devices. Centrifugally cast valve bodies of Type CF-8, weighing about 180 lb., are used in connection with the Atlas ICBM. Redesigned from welded construction at a cost saving of about 30%, these valves can withstand severe thermal and mechanical shock from –65° to nearly 500° F.

New Production Techniques – Greater use is being made of CO_2 molding. This new technique is especially advantageous in the production of cores. It is being extensively used with shell molding in high-volume production. Use of the shell molding process is growing, especially for volume production of such units as valves, pumps and fittings.

Exothermic materials are finding wider application, particularly where the production of larger castings is taxing melting capacity. The use of exothermic sleeves on risers permits more efficient use of available molten metal in the manufacture of some types of castings.

Trends – More high-alloy castings are being used because processing conditions are involving either more severe corrosion or higher temperatures. This is true in industries such as pulp and paper production, atomic energy, petrochemical processing and conventional power generation. There are several reasons for the trend: A wide range of cast alloys are available for heat resistant applications, and special compositions tailored to the requirements of specific uses can be obtained economically in the cast form. Under severe conditions, castings can be designed to eliminate crevices that might act as focal points for corrosion.

*Executive Vice-President, Alloy Casting Institute, Mineola, N.Y.

This Casting Is Made From A.C.I.'s New Hardenable Cast Stainless Alloy, Designated CD-4MCu. It is 12 in. high and 8 in. across the major diameter, with a cored out conical shape roughly approximating the outside shape. The casting will be used as a nozzle tip in a water jet pump employed for removal of power house ash. The ejector tip is age hardened to Brinell 321, after machining

Special Metal Articles Feature

Detroit Revisited—

Appraisal of Recent Metallurgical Advances in American Automobile Manufacturing

By J. L. McCLOUD

Among the recent changes and those soon to come in materials for automotive use, the trends toward low-alloy and carbon steels and toward greater use of aluminum seem the most significant. (T21, 17-57)

IN THIS HIGHLY COMPETITIVE American automotive industry, materials and methods of fabrication of tomorrow's cars are already under review. There seems to be a broad trend away from alloy steels or at least toward leaner tri-alloy steels. This means cost reduction, and such a policy is naturally most interesting when production rates and profits are low. Alloy almost axiomatically costs more than plain carbon steels.

Induction Hardening – Then, too, methods of heat treating have been so improved that even better parts are being made of these leaner steels than the alloy steels they replaced. An excellent example of this is the carbon steel axle shaft, induction hardened. It had been general practice in Detroit to make these of alloy steel and heat treat them to as high a level of hardness as could be economically machined. Now, these are widely manufactured of carbon steel – say A.I.S.I. 1040 – machined to approximately finished size, and then hardened on the bearing surfaces by induction. A finish grind completes the part. Such a manufacturing routine takes advantage of the internal stress residual in the part in service where the shaft is stressed in alternate bending. The surface layer in high compression improves the fatigue life. Not only is this principle being substantiated in laboratory testing but also in service.

Axles aren't the only shafts being so manufactured; transmission shafts follow this practice also. Induction hardening is being extended to such other places as truck valve seats; the cast iron of the blocks themselves is amenable to such treatment. A further use is for differential hardening of pinion seats instead of using bronze liners – an obvious cost advantage. However, induction heating may sometimes be over-extended. In at least one recent example, it was found more economical to cap the end of the part and go back to conventional carburizing; the cap not only protected the end of the part from carbon but slowed up adequately the cooling rate of that area in the direct quench.

Fig. 1 – More Aluminum Is Being Used in Trim Items and Castings. Photo shows aluminum parts used on the 1958 Buick

For years one auto maker has held out against gas carburizing, preferring to continue the older pack method, but now the gas process has found a place in his operations.

Unconventional Materials – Triple-alloy steels, a World War II development, are still being used to conserve alloys. However, experience with some parts has shown that the alloy content can be still further lowered. In one instance this resulted in a new single-alloy steel (the proposed S.A.E. 4427 with 0.50 Mo and 0.80 Mn). In another part the change was all the way to C 1041 with a shallow carburized case. No sacrifice in quality was noted.

From one company's pioneering of cast crankshafts, and their successful use by another manufacturer, has come a re-evaluation of castings to replace not only stampings but also forgings. One torque convertor reaction shaft has been changed successfully from C 1141 steel to a pearlitic malleable casting. Another change is a stamping of 1010 steel to the same pearlitic malleable; in this instance a considerable economy resulted from elimination of welding operations and the combining of several parts into a single casting.

The general swing toward aluminum has many reasons, outlined rather comprehensively by the Editor of *Metal Progress* in a Critical Point – "Light Metals in Our Two-Ton Autos?" – in the March 1956 issue. Its more general and popular interest is indicated by a recent story in a news weekly. A couple of the automobile companies have built foundries adjacent to plants producing aluminum; this has reduced handling and processing costs to the mutual advantage of both smelters and fabricators.

Aluminum castings for pistons have many advantages and have been widely used for a long time. Pistons, in fact, have consumed steadily about 40% of all the aluminum which went into automobiles. However, in the conventional alloys, the expansion is greater than desirable, and alloys with reduced expansivity are now being used to obvious advantage. Another aluminum property – good conductivity for heat – has led to radiator construction. Here it would replace copper which becomes so scarce during national emergencies, even though there is a glut on the market right now. Several problems in manufacturing aluminum radiators have been solved. The joining of aluminum may not in the future be as much of a deterent as it has in the past.

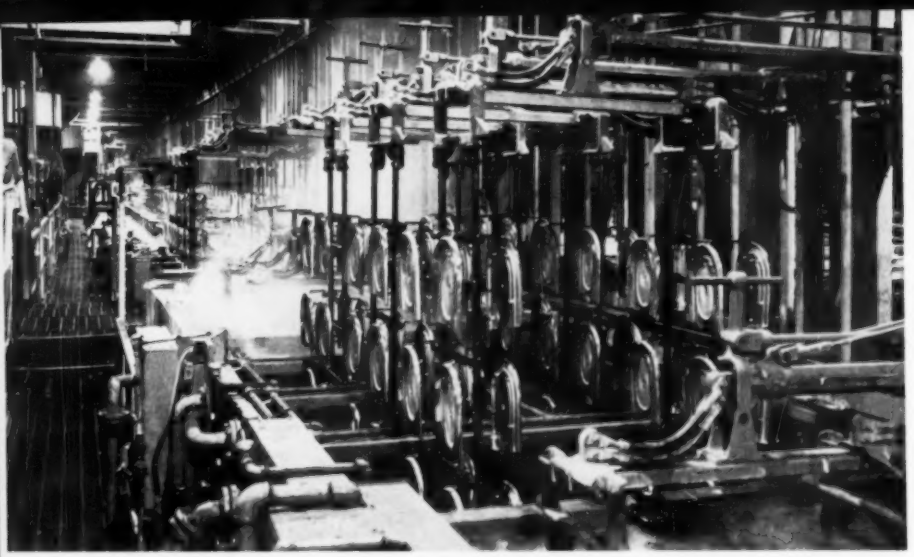


Fig. 2 – Ford Tail-Light Shells Are Chromium-Plated Automatically in This New Plating Installation at the Company's Sandusky, Ohio, Hardware Plant

Bright Work – But castings are not the only new use for aluminum in automotive construction. More than one company makes its bright decorative parts of sheet aluminum now. These are chemically brightened and subsequently anodized. This is a return to the practice of 20 or more years ago, dropped in favor of the even brighter nickel-chromium plating. It is coming back.

Another plating that has been losing out to aluminum is gold. Because of its cost, the gold was naturally spread pretty thin and the plated part didn't stand up well in service. Substantial use is now being made of anodized and dyed aluminum, either as castings or stampings. Dyes have been found that not only have the same color as gold but have excellent durability, so the designers can have their color and the service man no headaches.

The nickel shortage during the Korean war led to some studies to reduce its use. At least one car manufacturer successfully used white brass in place of nickel-plated parts. While some nickel is still used in this substitution, the quantity is less.

It probably is worthy of note here that *testing* the quality of protection and *maintenance of* bright work has been improved. For a long time the much maligned salt spray has been relied on. Now the American Electroplaters' Society has developed a "corrodkote" test that seems to be much more reliable and at the same time more searching. It is coming into general use in Detroit.

A financial daily which frequently leads in news releases, even of technical information, stated recently that some automobile makers will use more chromium-nickel-copper for plating their bright work, while the thicker "crack-free" chromium plate was to be used on the more expensive lines of cars. These statements are natural reflections of the improved supply picture – especially for nickel – from the car maker's viewpoint. They also reflect the competitive urge to improve quality.

While not about metal, new paints for metals are the "emulsion" finishes. Conventional paints that are thinned for use with organic fluids (generally petroleum or other liquid hydrocarbons) are bad fire hazards. New chassis blacks and rust protective primers are now in use that are "water thinned". The simultaneous elimination of fire hazard is an enormous step forward in plant safety.

Processing techniques have seen many improvements. Here one should list high the production of shell molds. Detailed advances have been in the method of coating sands with the required resins, requiring smaller quantities of expensive organics, yet producing molds not only as high or even higher in strength. These new molds are also more permeable to trapped gas. These shells are strong enough to be used without back-up materials such as sand or shot. Perhaps, too, the use of this general foundry technique to make cores is the next logical extension with important economic aspects. After all, a core must be removed from the casting. If the quantity of sand is reduced in the core, or if no strengtheners such as wires are required, the cleaning operation is facilitated.

Powder metallurgy is furnishing more parts to the automotive industry. These are generally based on iron, but may also be of the very high graphite compositions. The latter give superior performance as antifriction materials. Powder metal parts generally replace small castings, but may also be substituted for screw machine

parts. Cost is the principal motivation but there may be other advantages. For example, one such part has been found to resist brinelling by mating parts.

Valves are critical parts that need improvement. Aluminizing is a step in the right direction – not only for intake valves made of very mild or no alloy compositions, but also for the high-alloy valves. More than one manufacturer now coats the engine valves to protect them from burning.

Phosphate coating of gears is a spreading practice. It permits greater unit loading without any hazard in the "running-in" period, so critical in olden days. The same coating is in generally increased use on camshafts and tappets. Gears are frequently peened to improve their fatigue properties. This included transmission as well as rear axle gears.

A process interesting all the automotive plants is cold and hot extrusion, especially cold extrusion and spline rolling. True, upsetting has been in use for many years but now it is used for more and much larger parts. Shafts are forward and backward extruded with several required diameters; the steels are hard enough so they may be further cut for gears or flanges. These may then be heat treated as required or the hardened and strengthened cold worked metal used as such.

Variety of these extrusions ranges from hollow nuts to rather large drive pinions. Economies here again are the urge – there is always a considerable saving in raw material.

News from abroad has it that special processing of steel wires has produced tensile properties of the order of 500,000 psi. and elastic limits of 250,000 to 300,000 psi. These are said to be in use as reinforcing wires in tire construction.

It is with great sorrow that we must announce the death of Lans McCloud from a heart attack on the golf course at Los Altos, Calif., on Saturday, July 26. He served with distinction as consulting editor for *Metal Progress* since his retirement in mid-1956 from Ford Motor Co.'s engineering staff. This article was prepared during a fortnight's stop-over in Detroit in June, enroute to Boston, where he received an Honorary Membership and the Award of Merit from the American Society for Testing Materials.

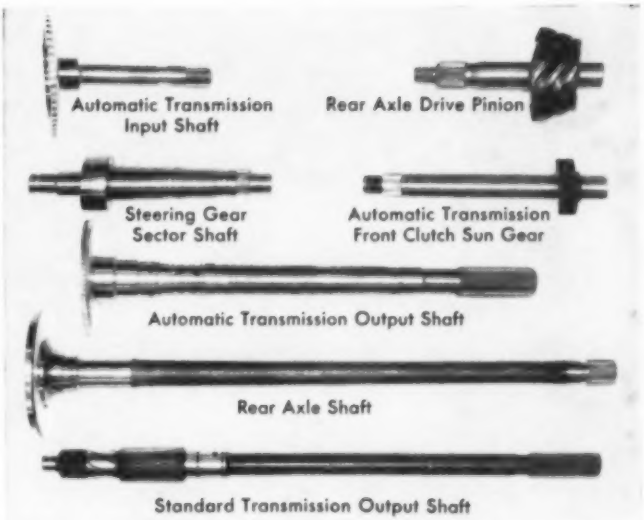

Automatic Transmission Input Shaft
Rear Axle Drive Pinion
Steering Gear Sector Shaft
Automatic Transmission Front Clutch Sun Gear
Automatic Transmission Output Shaft
Rear Axle Shaft
Standard Transmission Output Shaft

Fig. 3 – At Ford, Splines on Seven Production Shafts Are Being Formed by the Cold Rolling Process. This process, sometimes referred to as chipless machining, was first used at Ford four years ago and has replaced conventional methods of cutting these splines

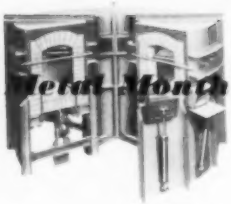
Vinyl-coated steel sheet is being formed after coating, with obvious advantages.

Iron Founding – Other interesting processes found in this general survey are in the foundry. Water cooled cupolas are more generally used. In these cupolas, the shell is not lined with refractory, but is cooled on the outside with water sprays. A layer of slag builds up in a desired fashion and thickness, adequately protecting the steel shell. At critical areas the inner protection may be of carbon blocks as in some blast furnaces. The particular advantage is that the cupolas are not down so often or so long for relining. Therefore, less equipment is required for a given monthly tonnage.

Cupola operation has long depended on the skill of the melter to determine when there was an adequate well of molten metal to permit economical tapping. Gages which use X-ray or radioactive isotopes are now able to show definitely how much molten metal there is in the hearth, and hence not only when to tap but how much to tap.

Conclusion – It's an interesting metallurgical industry, this automotive one. It's new and leans heavily on many old arts. Like its competitive sales organization, it is a dynamic one. The essential aim in the field of materials is always "More and more from less and less".

Special Metal Month Feature



Potential of Higher Temperature Carburizing

Manufacturers are becoming interested in carburizing at higher temperatures as a means for increasing production. First moves by heat treaters will probably be to the 1800 to 1850° F. range which will give carburizing rates about 50% higher than are obtained at 1700° F. Even higher temperatures may be used in the near future for thick cases on tractor gears and other heavy-duty equipment. Furnace problems appear to be solved but other problems must be considered in the heat treating and steelmaking areas. (J28g, 1-66, W27; ST)

THE CARBURIZING PROCESS, old as the Crusades, may be on the verge of a major revolution. In the near future, it appears that the carburizing temperature, long standardized in the 1650 to 1700° F. range, will be pushed to 1800° F., 1900° F., and even higher. Even now, furnace builders are erecting and testing furnaces that operate in the higher range, while heat treaters and steelmakers are getting interested. Despite the problems involved – and there are many – the promise of much greater production rates is too intriguing to pass up: Parts can be carburized in ⅓ to ½ the time it takes at 1700° F. Cases of more than 0.10 in. in thickness are produced in 8 hr. at 1900° F. Yet, before this new technique is established, many problems must be solved. Their ultimate solution is certain, although today little is being done because production is slack. The demands of tomorrow will undoubtedly spark a resurgence in research. As of now, our aim is to describe the potential and problems of higher temperature carburizing.

Theoretically, there is nothing particularly unusual about the fact that steel carburizes faster at higher temperatures. In the first course of high school chemistry, everyone learns that "Increases in temperature raise reaction rates". If, at 1700° F., carbon diffuses into steel with a given rate, it will diffuse more rapidly as the temperature rises. Higher production rates are obviously possible.

Under the circumstances, it may seem strange that most heat treaters haven't used higher temperatures for carburizing before this. The answer is obvious: With higher temperatures, *all* reaction rates increase. Furnace parts (rails, heating elements, fans) erode more rapidly. The grain size of steel in parts being treated increases with temperature. These and other drawbacks discouraged research for many years.

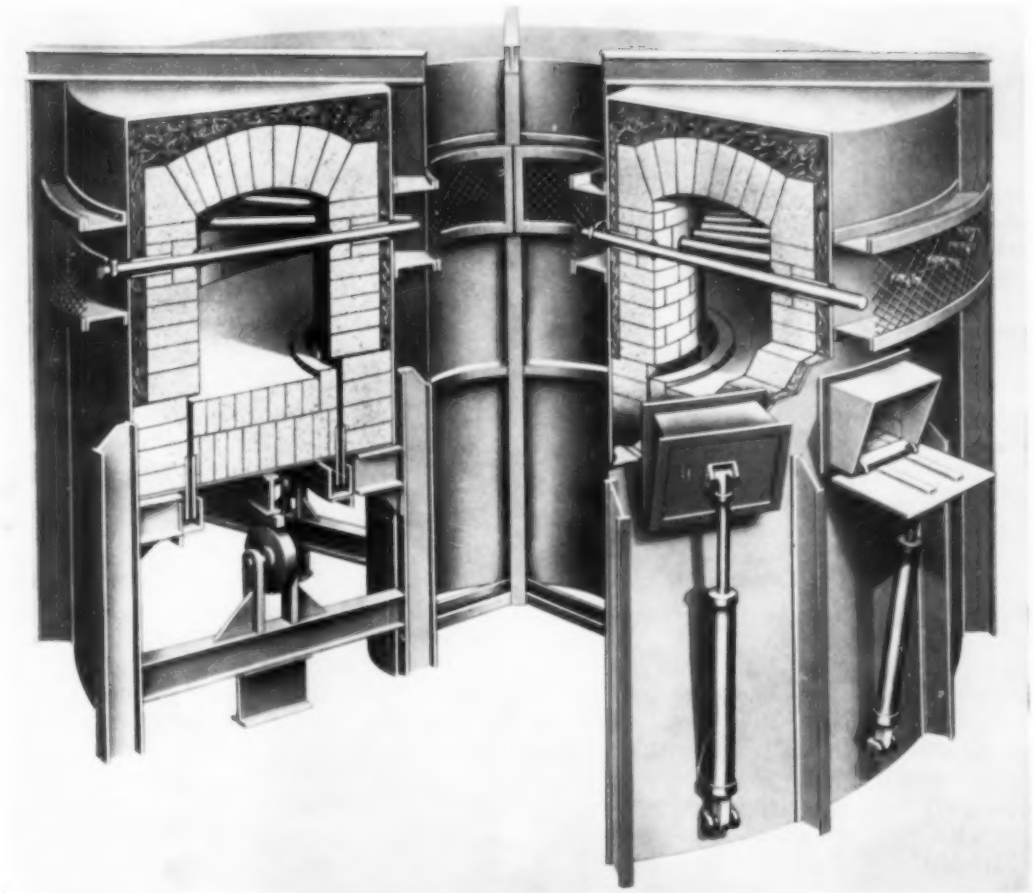


Fig. 1 – Drawing of One Type of Proposed Furnace for Carburizing at High Temperatures. Alloys are avoided in the high-temperature zone by rotating the entire hearth. The hearth is ceramic

Lately, however, the British and Russians have both reported progress in the field. The Russians, in particular, seem to have done much work. One report* claims that grain size is little affected at 1920° F.; grains do not have a chance to enlarge in the short time needed for an adequate case. The Russian workers deduce that carburized parts can be made in ⅓ to ½ the time required at 1700° F. Another interesting fact: They conclude that the carburizing rate depends on the number of times the gas is changed; the optimum, they feel, is 100 times per hr. Above this, spotty carburization can occur; below this, the carburizing rate may be lowered appreciably. Further, they reported no substantial changes in microstructure or mechanical properties.

Furnaces

With the announcement of this encouraging information, builders of carburizing furnaces in this country began to do more work. (Some, incidentally, have been building equipment which has been used for carburizing at 1800° F. and above for several years.) For a long time, progress had been retarded by the lack of truly adequate high-temperature alloys. Only ceramics could withstand the higher temperatures. While these were suitable for batch furnaces, they did not have strength enough for rails, trays and rollers in continuous furnaces. Alloys available were reasonably strong and lasted for fairly long periods at 1700° F. but deteriorated more rapidly above that temperature. Recently, however, suitable alloys have become available. The

* "High-Temperature Gas Carburizing of Steel", by G. M. Shuval, I. S. Lupakov and I. A. Feldman, *Metallovedenie i Obrabotka Metallov*, Vol. 2, No. 6, 1956, p. 49-52 (Brutcher Translation No. 3806).

wide interest in high-temperature problems has sparked continuing research for the last 12 years. In that period, both cast and wrought alloys durable above 2000° F. were developed; these were applied to furnace parts by builders. High-density refractories for hearths, ceramic-coated radiant tubes, and ceramic fans were also developed. With these high-temperature materials now in use, furnace builders quote on equipment which operates steadily at 1850° F.. Even higher temperatures are predicted for the future.

Batch-type furnaces are prabably the simplest since they usually have but one moving part – the fan which circulates the carburizing atmosphere. It can be made from either ceramics or alloys. For example, one builder uses a high-density refractory (consisting chiefly of alumina) for the fan and other hot parts. Excellent durability is claimed even at temperatures above 2000° F.

Continuous furnaces bring on added problems because there are more moving parts. The rails, trays and rollers on which the parts ride must be made of alloys that can withstand distortion and carburization for long periods. A popular alloy used by several manufacturers is NA 22 H (50% Ni, 25% Cr, 5% W, bal. Fe). Some furnaces employ a vertical radiant tube which is said to operate for at least 18 months at furnace temperatures of 1800 to 1900° F. This tube, made from a superalloy, is coated with a high-temperature enamel to retard carburization. The vertical design prevents sagging from creep, and soot cannot collect to cause hot spots.

Wrought alloys used by others for these furnaces include Type 330 and 310 stainless steels, Hastelloy "X", Multimet and Inconel; high-density centrifugal castings of a 35% Ni, 15% Cr alloy are also employed. Heating elements can be made of 80% Ni, 20% Cr alloy. Silicon carbide is used for rails inside some furnaces.

Design features, too, can sometimes sidestep the alloy problem. An example is the rotary furnace shown in Fig. 1. It avoids alloy baskets and rolls by rotating the hearth. No alloys are exposed to high temperatures and gases. The work is laid directly on the traveling hearth bed for carburization. Other systems are being employed. For example, salt baths are being used by some heat treaters to carburize in the 1800° F. range. One company is studying induction heating of parts at 2000° F. in an appropriate gas for carburizing.

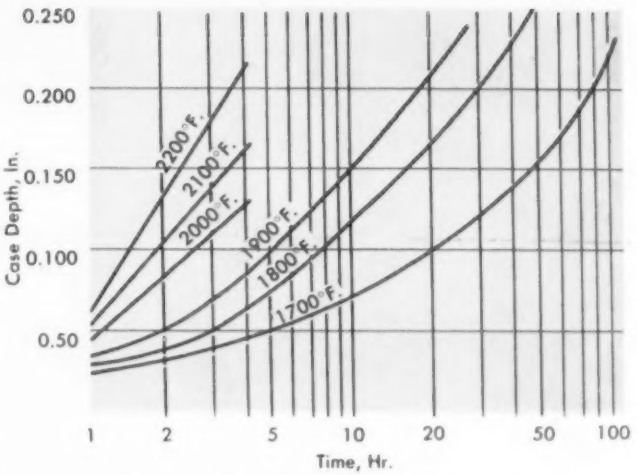


Fig. 2 – Case Depth Variations as a Function of Temperature and Time. Data are for 1018 and 1117 steels

Experimental Work

With these improved furnaces, it has been possible to find out something about the characteristics of higher temperature carburizing. Furnace builders, heat treaters, and steelmakers all became interested, some to the extent of large research programs. Enough data have now been released to give a fairly accurate picture of both advantages and disadvantages.

The obvious advantage of faster rates and shorter times at once became apparent. The curves in Fig. 2 depict case depths achieved at various temperatures and times; as expected, higher temperatures increase carburizing rates greatly. Take one example: For a 3-hr. period, the depth is increased from 0.040 in. to 0.200 in. when the temperature is raised from 1700 to 2200° F.

These extremely rapid carburizing rates bring their own problems. When the cycle begins, steel soaks up carbon like a sponge soaks up water. (At 2000° F., for instance, carbon penetrates 0.009 in. *the first minute.*) Thus, at the start, a rich hydrocarbon mixture must be continually maintained; conversely, at the end, the gas has to be lean to prevent build-up of carbides on the surface. A gas generator equipped to provide a variety of mixtures is essential. This can be done by combining generator gas with hydrocarbon gas or air.

Another problem to be considered is the extreme absorption of carbon at the surface of the part being carburized. The percentage of carbon rises to 1.6 and even above if not controlled. Fortunately, most furnace builders have equipment to control the surface carbon, and this difficulty is not as serious as are some of the others.

The graph shown in Fig. 3 indicates that the surface carbon can be controlled within 0.10% in a 300° F. range. At 2000° F. it is also apparent that a gradually sloping carbon gradient is present. This is an advantage since abrupt changes in carbon content below the surface may lead to spalling.

Another difficulty is grain growth at these temperatures. In fact, this is the chief drawback to acceptance of higher temperatures for carburizing. Some growth occurs in the 1825 to 1850° F. range, and the rate is substantially increased above this temperature. If grain growth is limited by using short time cycles, the case may be too thin. An example of grain growth in 8620 steel, carburized for 3 hr. at 1900° F., is shown by Fig. 4. Coarse grains can be eliminated by re-austenitizing below 1700° F. to give a double treatment. Quenching from the lower temperature also reduces distortion. However, this is an extra operation; the time gained by the faster carburizing rates may be lost in the added heating. Further, more furnace capacity is needed.

At present, there is the feeling that higher carburizing temperatures will be most valuable for producing heavy cases. Cycles of 96 hr. or more, now needed for thick cases on heavy-duty tractor gears and the like, can be shortened drastically. The time needed for reheating to refine the grain is determined only by the geometry of the part; thus, there is an appreciable saving in total time. There is already some interest in this phase of higher temperature carburizing; at least four major builders of heavy equipment are known to be doing some work. Since it also appears that the future will see more heavy equipment for road building and military use, the production of heavy cases will apparently be the first practical application for higher temperature carburizing.

Little worry is expressed concerning the mechanical properties resulting from the use of higher temperatures *provided a fine grain size is maintained.* Actually, grain size has little effect on these properties anyway; coarse grains promote other difficulties such as quench cracking, distortion, and brittle failures.

Summing up the furnace builder's story, they appear to be ready. Ingenious design, better alloys and ceramics have practically solved their problems for 1850° F. operation. The near future will bring furnaces that can operate satisfactorily at 2000° F. and above.

Carburized Parts

Meanwhile, what about the heat treaters — those who carburize the gears, shafts, and other parts that go into the millions of machines made in this country every year. Are they pleased with prospects for higher temperature carburizing? Frankly, they're not sure. While they recognize the fact that more parts can be made in a given time, they question the added expense of the process.

One deterrent is their big investment in equipment which operates capably at 1700° F. Conversion to 1800° F. operation — they feel this may be the upper limit for practical use — is not difficult, but is still beyond their desires in many

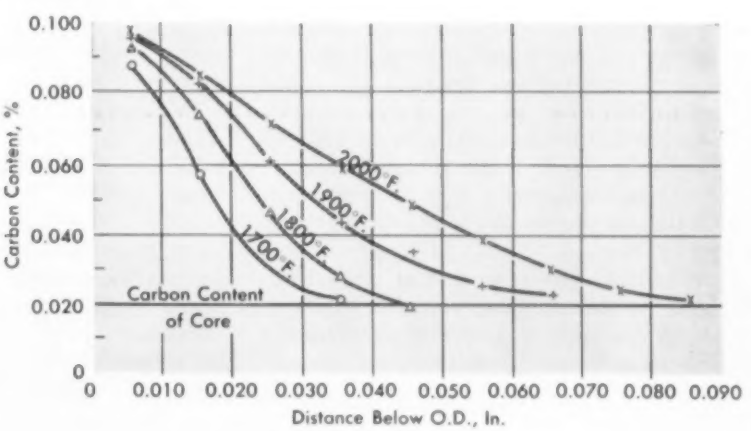


Fig. 3 — Carbon Gradients at Various Carburizing Temperatures. The gradient slopes more gradually at higher temperatures because of increased diffusivity. The surface carbon has been controlled at 0.9 to 1.0% C for these tests

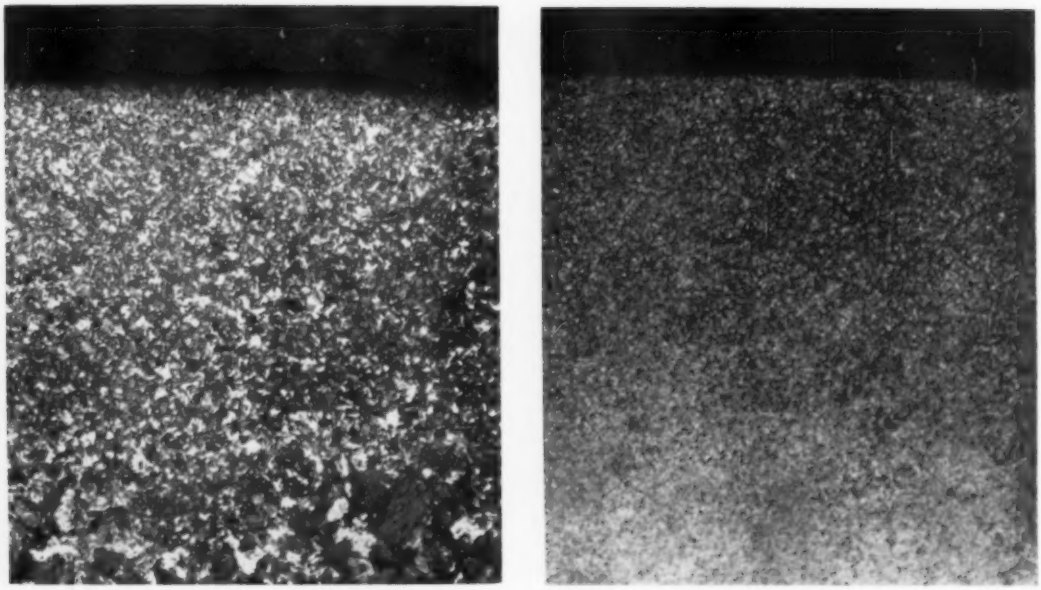


Fig. 4 – Microstructures of 8620 Steel After Carburizing at 1900° F. for 4 Hr. Reheating at 1500° F. has refined grains formed during the carburizing operation. Magnification, 100 ×; 2% nital etch

instances. This is especially true for carburizing furnaces tied in with assembly-line production. While more gears and shafts could be made, to be useful all other assembly operations would have to be speeded up. A few who anticipate increased production are asking for quotations on furnaces that operate at 1850° F. As time goes on, more should get interested.

The problem of grain growth is the greatest inhibiting factor in the adoption of the process. Since steelmakers cannot guarantee a fine grain above 1700° F., heat treaters might be forced to refine the grain of carburized parts by reheating. Heat treaters who are equipped for reheating can make profitable use of higher temperature carburizing techniques (some do, in fact). To others, higher carburizing temperatures would mean the addition of reheating furnaces. Consequently, most interest is limited to the 1800° F. range. Grain growth is not so likely to be a problem, particularly for the shorter times needed to form cases equivalent to those formed at 1700° F.

Most heat treaters concede that carburizing at higher temperatures has possibilities. Since its greatest advantage – increased production – is not needed at present, the majority of heat treaters have done little more than discuss the process.

Steel

As the foregoing shows, most of the problems stem from the phenomenon of austenitic grain growth at elevated temperatures. Steelmakers refuse to guarantee fine grain above 1700° F., not from blind prejudice, but because they are fully aware of the problems of grain refinement. They know that aluminum, the usual deoxidation and grain refinement addition, can produce a fine-grained steel to 1900° F. and above (see Fig. 5); they also know the effect is not consistent and cannot be predicted. The grain can coarsen as low as 1750° F. Furthermore, the grain coarsening temperature can vary from heat to heat, within the same heat, and sometimes within the ingot.

Under these conditions, ingots of steel for carburizing at 1800° F. and above would have to be tested individually to determine the grain coarsening temperature. Imagine the work involved! A large number of McQuaid-Ehn tests, the standard in the industry for grain size determination, would be required for each heat. These would necessarily be heated at the desired carburizing temperature and time depending on the customer's wishes. What this would mean in terms of extra work (not to mention furnace wear) is beyond calculation now.

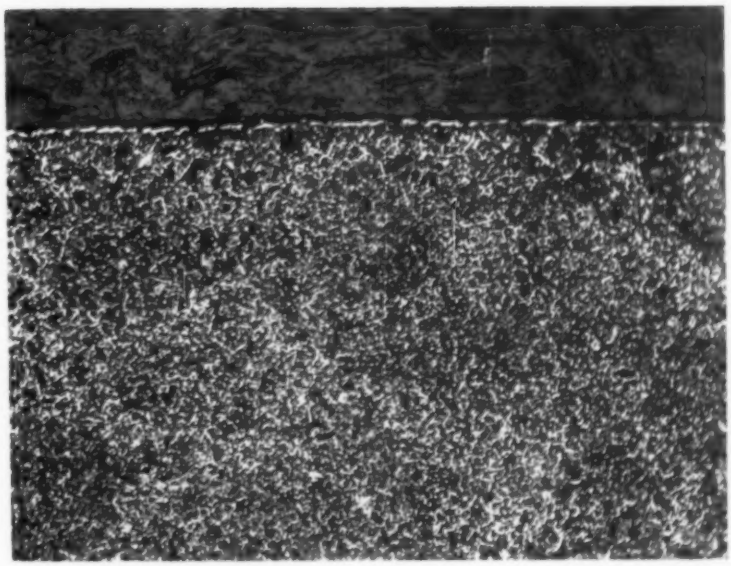


Fig. 5 – This is 8620 Steel After Carburizing 12 Hr. at 1900° F. Comparison with Fig. 4 will show that grain size in this specimen is finer. This difference in response is a characteristic of the steel; two different heats are involved. 100 ×; 5% nital etch

At present, steelmakers feel that the process has not been developed to the point where the needed extensive research would be profitable. They know today that the optimum amount of aluminum will prevent coarsening to about 1850° F. (This figure is a statistical average; it indicates only that half the heats will coarsen above 1850° F. and the other half will coarsen below 1850° F.) Any further increases in grain coarsening temperature will have to be achieved by other addition agents, either by themselves or in conjunction with aluminum. Previously, titanium, zirconium and vanadium have also been used as grain refining agents. Published information (Metals Handbook, 1948 Edition, p. 478) shows that titanium and aluminum together raise the coarsening temperature above 1950° F. Vanadium and zirconium are not as effective. Columbium has been patented as a possible grain growth inhibitor.

It appears that the problem's solution will require fundamental research into the true nature of grain refinement. While it is known that aluminum is effective, no one is sure of the actual mechanism. Some feel that submicroscopic oxides inhibit growth; others are equally sure that aluminum nitrides supply the active agent. To speculate a bit, researchers may solve the problem through the back door. Instead of adding supplemental elements, they may succeed by adding oxygen (through adjustment of bath deoxidation) or nitrogen (in a solid form such as calcium cyanamide).

However, the actual method to be used for grain control at the required temperatures is still in the future. Steelmakers admit they are looking into the problem, but have nothing definite to report.

So where do we stand? Enough work has been done to prove that carburizing at higher temperatures is definitely feasible, and only a little more cooperative effort should be needed for production use. Economic conditions are limiting activity for the moment. Carburizers are not too interested in making parts faster when they can't sell the ones they make now. The added cost for new equipment is another deterrent. When the demand grows greater, activity on the higher temperature carburizing front will increase; the tools are ready and waiting to be used.

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Special Metal Month Feature

Better Metallographic Techniques . . .

Metallography of Disturbed Uranium Surfaces

*By H. P. ROTH and R. B. RUSSELL**

Fig. 1 – 4/0 Emery Paper

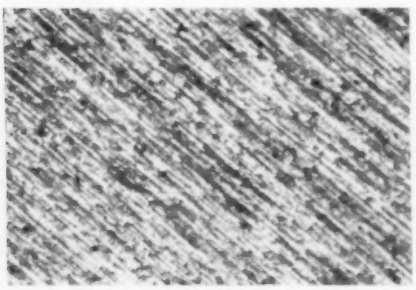
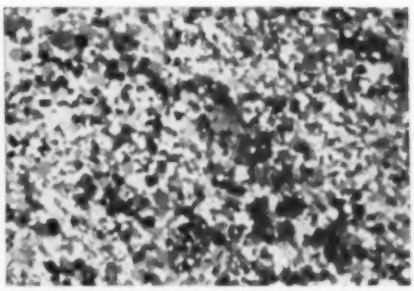
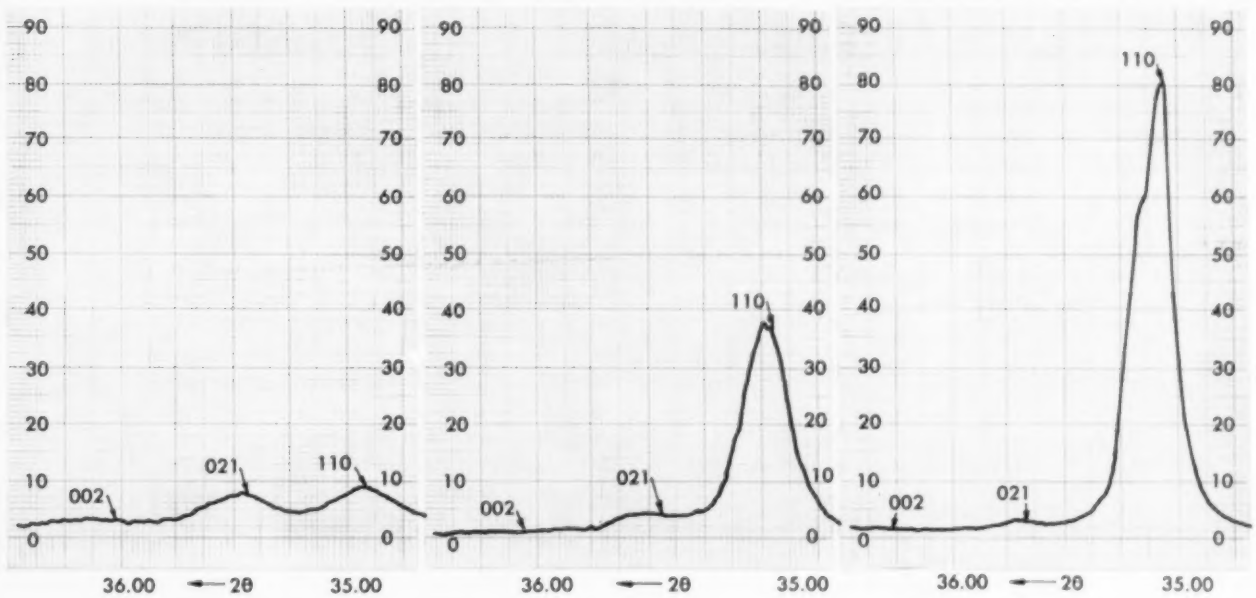


Fig. 2 – Cloth Wheel

Fig. 3 – 20-Sec. Electropolish





X-RAY DIFFRACTION STUDIES of uranium certify to the wisdom of often-repeated advice: Use both optical and X-ray metallography to reach sound judgments in physical metallurgy. Uranium is so opaque to 1 Å X-rays that they penetrate only a few ten thousandths of an inch; consequently the X-ray diffraction peaks are extraordinarily sensitive to the amount of surface deformation caused by metallographic preparation. In studying preferred orientation or texture in uranium, we have found that we must be sure we have removed the entire worked surface. This can be determined by X-ray diffraction tests of repeatedly polished surfaces, continued until the diffraction peaks are nearly constant.† For example, a certain banding of the uranium grains has been observed under the microscope. X-ray diffraction often shows this to be due to the vestiges of scratches from surface preparation, rather than from any fabrication or heat treatment.

An example of how information from microexamination and X-ray diffraction may work together is shown in the engraving. The micrographs represent a transverse section of an extruded uranium rod which was known to have a texture in which the (110) poles are strongly oriented parallel to the extrusion direction. The photomicrographs, which illustrate different stages of surface preparation, may be compared with each other and to their respective diffraction traces (2θ scans).

Figure 1 shows the scratches caused by 4/0 emery paper, and the X-ray diagram illustrates the broadened lines that are characteristic of a cold worked sample.

Figure 2 indicates that the emergence of the grains (through cloth lap polishing with Linde A in aqueous 10% oxalic acid) is associated with a substantial increase of diffracted intensity of the (110) peaks combined with a corresponding decrease of the (021) and (002) peaks. Their relative intensity changes and their decrease in line breadth show that the texture, average particle size, or stored energy content of the crystallites just under the 4/0 abraded surface is different from that which exists at the very surface.

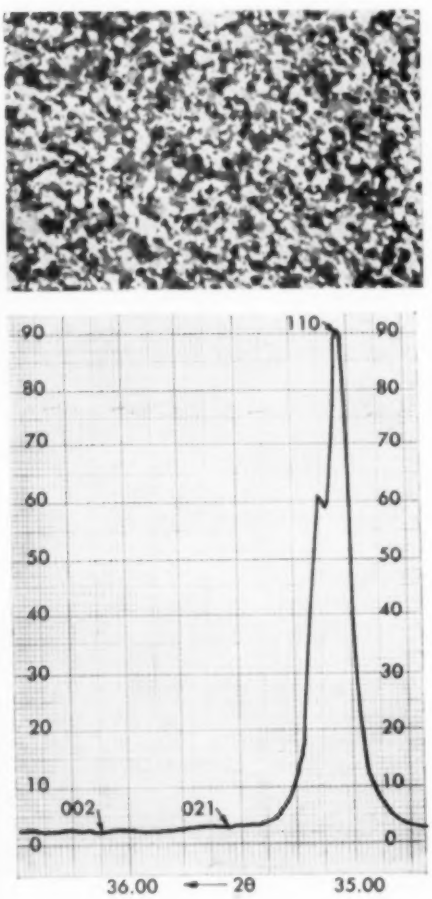
In Fig. 3 one sees that only a little electrolytic polishing‡ increases the contrast between grains under polarized light and also peaks up the (110) line. However, it will be observed in Fig. 4 that banding is still visible after electropolishing for 180 sec. The slight difference in brilliance or relative grain contrast and banding between Fig. 3 and 4 is, however, shown up very effectively by the greater intensity and resolution of the (110) peak from the surface electropolished for the longer time.

While this shows that the smeared or cold worked surface grains have been almost entirely removed by electropolishing for 180 sec., in our practice this polishing is continued for about 300 sec. and is even repeated if necessary according to the X-ray indications.

*Nuclear Metals, Inc., Cambridge, Mass.

Relation Between Microstructure and X-Ray Diffraction Intensity and Resolution From Orthorhombic Uranium. Micros at 75 × under polarized light

Fig. 4 – 180-Sec. Electropolish



†This of course demands rigid mounting of the sample in the holder which is placed in the diffractometer, because small differences in position can cause large intensity changes by defocusing.

‡Electrolyte composition by volume: 1 part H_3PO_4, 2 parts H_2SO_4, 2 parts H_2O. The sample is anodically polished and continuously brushed with a camel's-hair brush using a current density of 0.6 to 0.8 amp. per sq.cm.

Better Metallographic Techniques . . .

Polishing Hard Metals Electromechanically

*By J. M. DICKINSON**

A new technique simplifies metallographic preparation of high-melting metals and their alloys. By simultaneous use of mechanical and electrolytic polishing, layers of worked metal are avoided, and an exceptionally smooth surface is produced in a short time. (M20p; SGA-q)

METALS difficult to polish by usual methods (such as tungsten, rhenium, molybdenum, and their alloys) can be easily polished by a new electromechanical method. Smooth surfaces, free from disturbed layers and retaining most inclusions, are obtained in less than 5 min. The method is fast and can be easily learned.

Equipment

Electromechanical polishing, in essence, consists of applying a d-c. voltage to a specimen while slowly abrading it on a polishing wheel covered with an abrasive-electrolyte slurry. Several important variables control the quality of the polish. These are: Type of abrasive, type of polishing cloth, current density, pressure between specimen and wheel, speed of wheel, time, and polarity.

As Fig. 1 shows, flexible wires with alligator clips are connected to the specimen and to a convenient ground. These leads can be automatically reversed every 1.5 sec., or operated manually to allow choice of polarity. (Normal polarity was defined as the specimen positive with respect to the polishing wheel.) The d-c. power source was isolated from the power line so that either side of the output could be grounded. Direct current up to 5 amp. was available at 0 to 100 v.

Current densities of 0.01 to 0.1 amp. per sq. cm. were normally satisfactory, but occasionally densities as high as 2 amp. per sq cm. were used. In general, the highest current density that could be used without causing filming or uneven attack of the specimen surface was the most satisfactory. By changing the current densities,

*Staff Member, Los Alamos Scientific Laboratory of the University of California, Los Alamos, N. M., J. L. Lunsford, T. J. Ready and L. S. Richardson also supplied material for this article.

Fig. 1 – Electromechanical Polishing Apparatus. Note wire which leads to specimen

some materials could be given an excellent etch on the polishing wheel.

Forstmann or silk velvet made satisfactory polishing cloths. Linde A and B alumina were the most useful abrasives. Of the several electrolytes tried, these were the most satisfactory: a saturated solution of potassium ferricyanide; a 3% solution of hydrogen peroxide; and a saturated solution of sodium chlorate.

The polishing conditions for a number of metals are listed in the Table. It should be pointed out that other variables which are hard to define accurately, such as the pressure on the specimen are nevertheless important.

Experimental Work

All of the specimens examined during this investigation were ground through 600-grit silicon carbide paper lubricated with water. Most specimens were then ground through 4/0 emery paper. The same specimens were given different final polishing treatments to compare electromechanical polishing, electropolishing, etch polishing, and diamond abrasive polishing. After each final polishing treatment, the samples were reground on silicon carbide paper.

One experiment which demonstrates the effectiveness of electromechanical polishing employed

Electromechanical Polishing Conditions

Material	Polishing Cloth*	Electrolyte	Polarity	Current Density†	Time
Re	Forstmann	saturated $NaClO_3$	cyclic	0.1	2 min.
Mo	Forstmann	3% $K_3Fe(CN)_6$	reverse	0.01	5
	silk	3% H_2O_2	cyclic	0.01	5
W	Forstmann	saturated $K_3Fe(CN)_6$	normal	0.04	2
	Forstmann	3% H_2O_2	cyclic	0.04	3
Cb	silk velvet	3% H_2O_2	cyclic	0.01	5
ThO_2-W	silk	3% H_2O_2	cyclic	0.04	5
		saturated $NaClO_3$	cyclic	0.04	5
		saturated $K_3Fe(CN)_6$	normal	0.04	5
Re-W	Forstmann	saturated $K_3Fe(CN)_6$	normal or cyclic	0.04	2

*Al_2O_3 was used as the abrasive in all instances.
†In amp. per sq.cm.

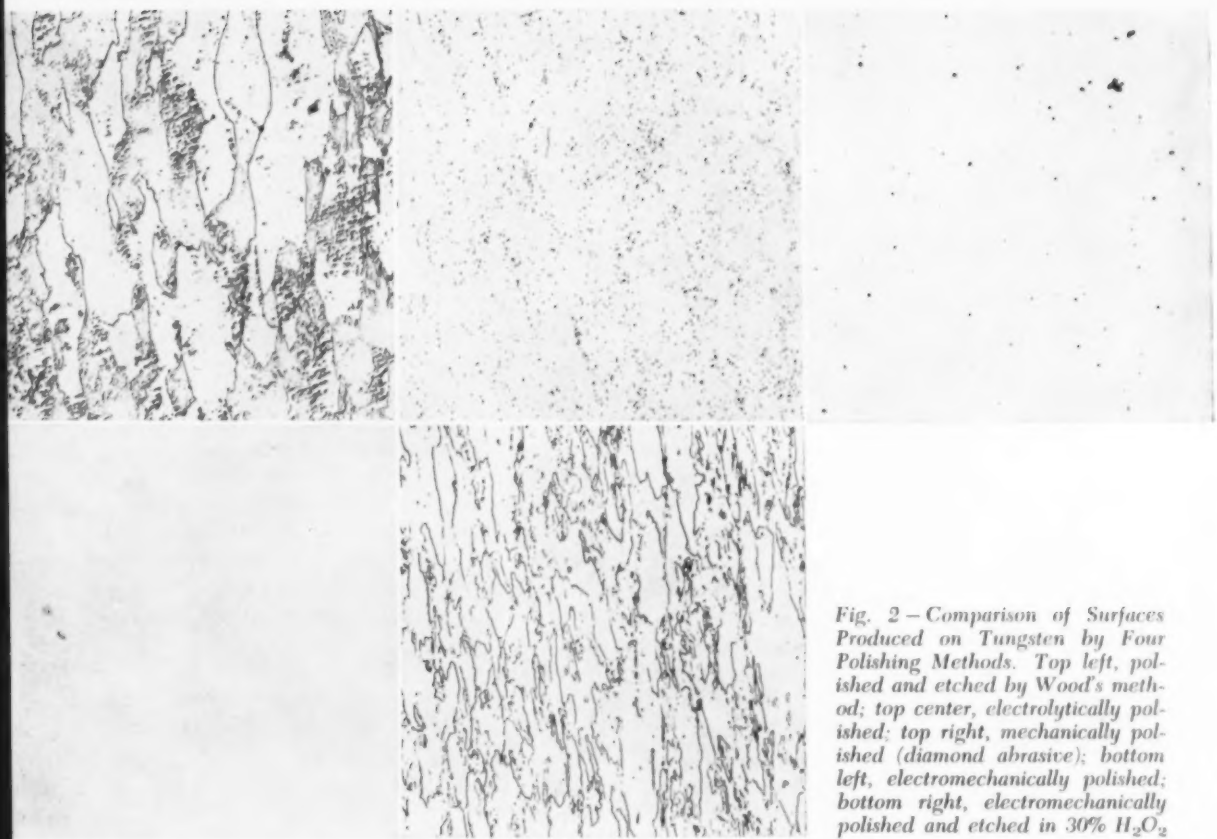


Fig. 2 – Comparison of Surfaces Produced on Tungsten by Four Polishing Methods. Top left, polished and etched by Wood's method; top center, electrolytically polished; top right, mechanically polished (diamond abrasive); bottom left, electromechanically polished; bottom right, electromechanically polished and etched in 30% H_2O_2

Fig. 3 – Polishing by Electromechanical Methods Retains Inclusions. This dispersion of thorium dioxide in tungsten has been polished for 4 min.

a sintered and swaged bar of tungsten. Four different polishing techniques were used. Three of them could produce an unetched surface, while the fourth, Wood's method, always produced an etched surface. Electropolishing normally gave scratch-free surfaces, but almost invariably produced some pitting. The same was true of diamond abrasive polishing; this also resulted in a worked surface and required excessive time. Electromechanical polishing, on the other hand, produced an excellent surface in less than 5 min. after grinding through 4/0 emery paper. Figure 2 illustrates photomicrographs of the tungsten bar after polishing by all four methods, and after etching with 30% hydrogen peroxide.

One of the striking results of electromechanical polishing has been the excellent retention of inclusions. A dispersion of 15% thorium dioxide in tungsten is shown in Fig. 3. This specimen was reduced approximately 50% by rolling.

Although the method was developed for use on refractory metals, it should prove useful for other materials, especially those which are difficult to polish. Inclusion retention, for example, is a tough problem; we feel that electromechanical polishing provides a workable answer.

Better Metallographic Techniques . . .

Polishing by Vibration

*By E. L. LONG and R. J. GRAY**

A new technique makes it possible to polish up to 24 specimens at a time without attention by a metallographer. Surfaces are generally better than can be achieved by hand polishing. (M20p)

ROUTINE METALLOGRAPHIC POLISHING has been improved by innovations which give smoother surfaces in less time. One of the most important of these is vibratory polishing, introduced only two years ago. As described in *Metal Progress* for aluminum (July 1956, p. 81), several samples can be polished at one time and a great amount of the hand work is eliminated. Thus the method is ideally suited to a laboratory, which processes a large number of specimens annually.

In November 1956, we bought a small vibratory lap-polishing machine and in a two-month period tried various abrasives, cloths, speeds, weights, and samples on the 5-in. diameter bowl. Results were most encouraging, but two difficulties had to be eliminated. The polishing speed was too slow, and the polishing bowl was too small. Then three larger vibratory polishing machines* equipped with 12-in. diameter bowls were secured. As received, the bowls were fastened to the polishing unit. The machines were adapted for quick-change bowls to facilitate cleaning; this also allowed a supply of bowls containing various abrasives to be kept on hand. Figure 1 shows these polishers with adaptors. With the large polishing machines, 24 specimens could be polished at a time with speeds up to six times that of the smaller machine.

Equipment and Procedure

In essence, as Fig. 2 shows, the vibratory polisher consists of a base-power unit, housing the spring and magnet assembly, and a flat-bottom bowl containing the selected polishing cloth or abrasive paper. Attached to the electromagnet armature is the bowl-mounting plate. Directly under and facing the armature is the coil and core assembly, which is anchored to a large heavy-base casting. The bowl-mounting plate is supported by four-leaf springs spaced 90° apart and at an angle of 65° to the base casting.

When the coil is energized, the armature, bowl-mounting plate, and bowl are sharply pulled down and away from the specimen. Because of the angular leaf-spring arrangement, a slight radial twist is imparted to the bowl with the downward movement. The inertia of the specimen keeps it from moving with the bowl, and the specimen then drops vertically to a new spot on the polishing cloth slightly forward of the initial position. When the coil is de-energized, the springs return the bowl to its original position, thus advancing the specimen. This happens 60 times per sec.

However, for any polishing action, the specimen should be heavy enough so that slippage between the specimen and the cloth occurs during the spring-back cycle. An optimum weight must be used so that the most polishing occurs with the least directional polishing. Directional polishing is prevented by allowing the specimen to travel enough to permit rotation during polishing.

The key to vibratory polishing lies in a setup properly designed to assure a tuned-spring system. Specifically, the tuned system should be

*Syntron Co., Homer City, Pa., Model LP-O1.

*Staff Member and Head, respectively, Metallography Section, Metallurgy Div., Oak Ridge National Laboratory, Oak Ridge, Tenn.

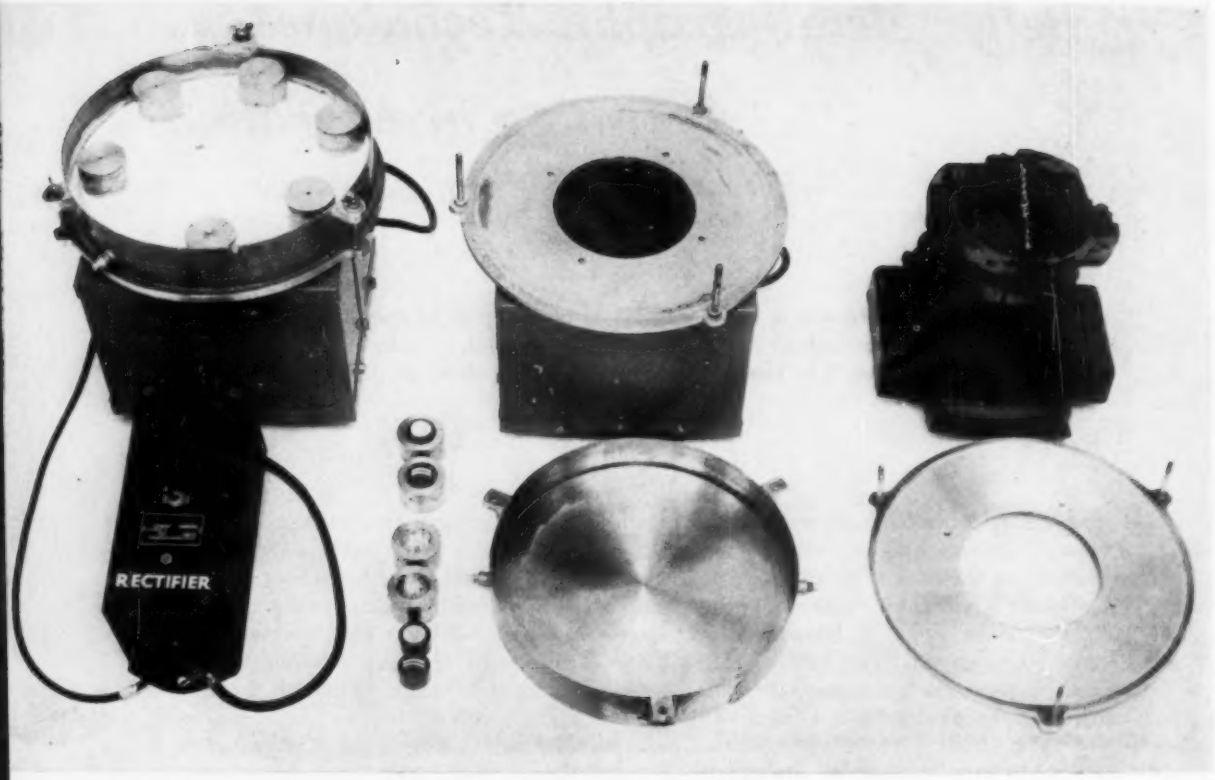
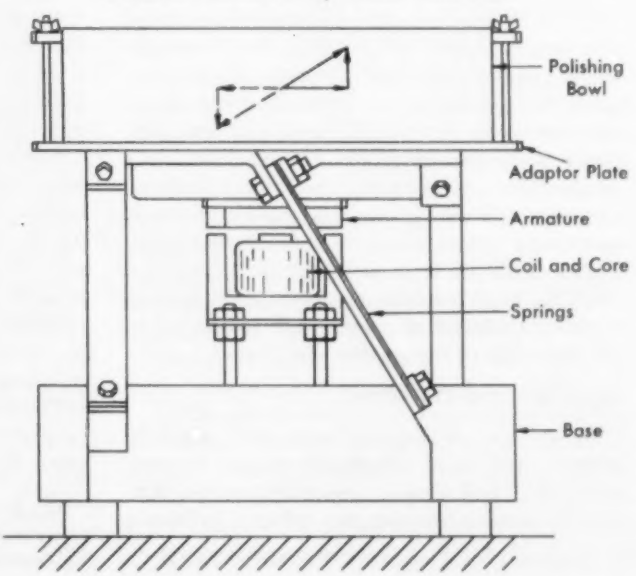


Fig. 1 — Vibratory Polishers With Auxiliary Quick-Change Equipment. Each bowl is 12 in. in diameter and takes up to 24 specimens at a time

three to five cycles higher than the frequency of the supply current. (For example, a 60-cycle polisher should have a period of 63 to 65 cycles.) The selection of such a frequency range eliminates harmonic motion and insures stability of the polisher.

The polishers are powered by a 60-cycle current passed through a half-wave selenium rectifier. This cuts out half the sine wave and the current flows in one direction only. Thus, the coil of the electromagnet is energized once per cycle. The specimen moves approximately 0.030 in. per cycle, but at this frequency the displacement cannot be seen. Instead, the specimens appear to flow smoothly around the periphery of the bowl. While the frequency is constant, the amplitude can be varied by

Fig. 2 — Sketch Showing Various Parts of Vibratory Polisher. The vectorial diagram indicates direction of bowl movement



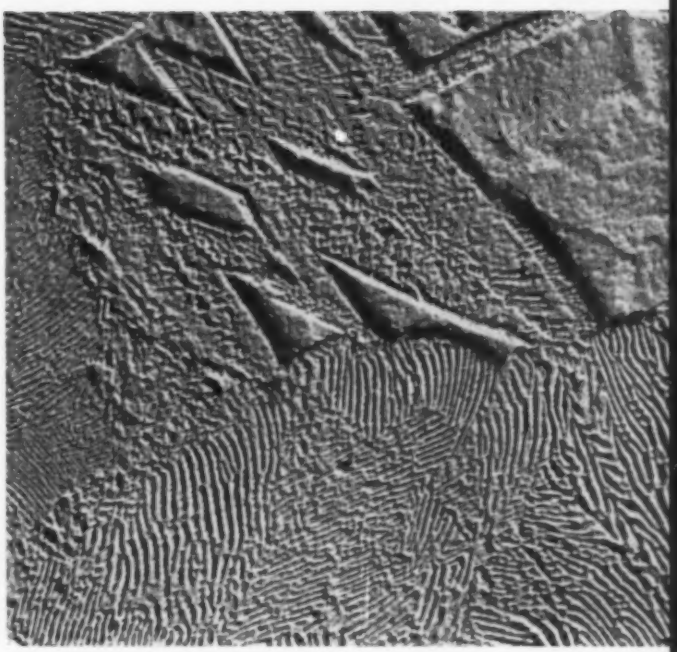


Fig. 3 – Electron Photomicrograph Showing Fine Pearlite. Smearing and scratches are not present. This was etched in a mixture of HCl gas dissolved in ethyl alcohol and 5% trichloracetic acid. Micrograph taken at 26,000 ×; reduced to 16,250 × in reproduction

control of the power input, thereby varying the polishing speed.

The work has included samples ranging in hardness from gold to boron carbide and in size from wires 0.019 in. in diameter to specimens 2 in. in diameter. Two types of cloths are employed – a good grade of silk (held to the bowl by a steel band) and a stiff deep-nap cloth (glued in place).

Most specimens processed here are mounted in the 1¼-in. diameter mounts. Since it has proved uneconomical to lap the specimens on the vibratory polishers, they are hand-ground through the 600-grit or 3/0 abrasive papers. Some specimens are still carried through the lead laps; however, use of these laps has dropped considerably since the introduction of the vibratory polishers. It has been found that an additional weight in the form of a stainless steel cap must be placed on the specimen before polishing. From experience the optimum weight for a variety of samples seems to be approximately 350 g. The specimens are then ready for the polishers.

Two variables affect the polishing speed – the weight on the specimen, and the amplitude of vibration. When a constant weight is used on the specimen, all variables except amplitude are eliminated. The rheostat setting is rather critical; if too low, slow directional polishing occurs, if too high, the specimens will bounce and little or no polishing will result. It is better to begin with a high rheostat setting and gradually reduce the speed. When the correct polishing speed has been attained, the specimens will not bounce. Instead, they will flow smoothly around the periphery of the polishing bowl counterclockwise while turning slowly with a clockwise motion. The polishing operation is a three-stage sequence. The average specimen requires a polishing time of 15 to 30 min. in the silk bowl with a 0.3-micron alumina slurry, then 15 to 20 min. in a bowl containing a deep-nap cloth charged with a 0.3-micron alumina slurry. A final polish of 20 to 25 min. is given in a third bowl with a deep-nap cloth charged with a 0.1-micron alumina slurry.

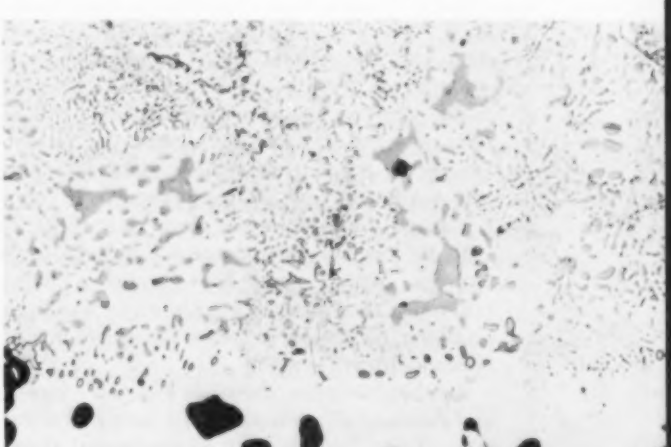


Fig. 4 – Nickel-Molybdenum Alloy Which Has Been Nickel Plated, Silver Plated and Brazed With a Copper-Silver Eutectic. There is no relief and only slight rounding of void edges. This is etched in a solution of 3% H_2O_2, NH_4OH, and H_2O in equal parts. 250 ×

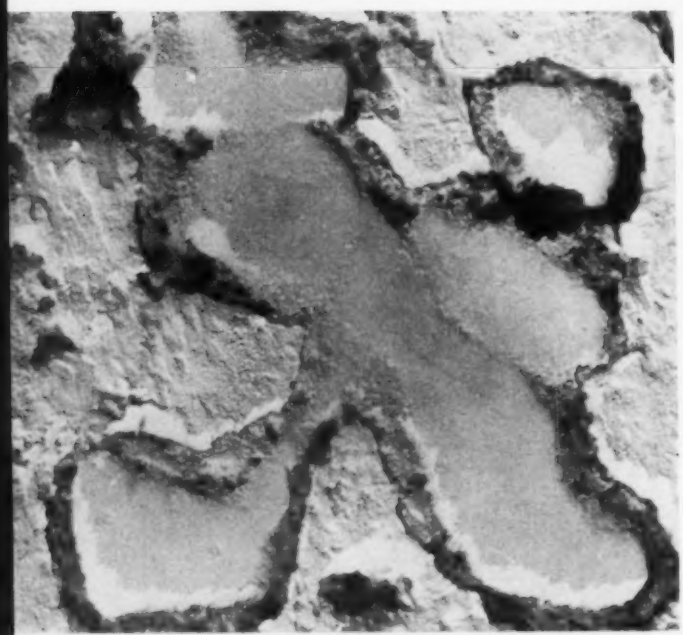


Fig. 5 – Electron Photomicrograph of a Europium Oxide Particle in a Stainless Steel Matrix. This is a carbon replica (preshadowed with palladium). Micrograph taken 22,600 ×; reduced to 13,500 × in reproduction

Applications – We have now studied many different types of specimens on this equipment. For example, to acid-test the method for directional polishing and smearing, a plain carbon steel sample was selected. This particular specimen had been isothermally transformed from austenite at 1100° F. for 1.6 sec. and quenched. Small pearlite colonies with extremely fine lamellar spacings resulted. Because the pearlite was much too fine to resolve under the light microscope, a palladium preshadowed carbon replica of the sample was made and examined with the electron microscope for defects in the structure which could have occurred during polishing. A typical area is shown in Fig. 3; no polishing defects were observed except for an occasional small scratch.

Another specimen, shown in Fig. 4, is a nickel-molybdenum alloy electroplated with nickel and then silver. Brazing with a commercial silver-copper alloy followed. The specimen has been polished to a scratch-free condition, yet there is no detectable relief-polishing between any of the constituents (though there are considerable differences in hardness), nor is there any excessive rounding of the void edges.

Extreme care in polishing was also needed on another occasion. Electron microscopy was essential to determine whether any reaction had occurred at the interface of a europium oxide particle surrounded by stainless steel. The sample, shown in Fig. 5, is in an as-polished condition with the reaction layer clearly seen surrounding the europium oxide particle. We later proved that silicon in the steel was responsible for this layer.

Summary – During the 14-month test period in which samples of practically every description were tried on the vibratory-polishing machines, many advantages have appeared.

As an instance, in contrast to automatic polishers, vibratory polishing is a continuous process – not a batch process. Frequently in the automatic polishing operations, one or two of the samples will require additional work during or after the successive stages of polishing. With vibratory polishing, no minimum number of specimens is required – from 1 to 24 specimens can be polished simultaneously. Furthermore, to check the operation, one specimen can be removed from the bowl and examined without interrupting the remainder of the specimens.

With conventional hand-polishing techniques, the metallographer devotes all his time to the polishing operations. However, with vibratory polishing, he is free for other duties while the specimen is being polished. Also, overpolishing is less likely to occur; if a specimen should remain in the polishing bowl for an additional 5 to 10 min., it is unlikely that repolishing would be required.

It takes less time to train people to use this method. It does not tax the operator's patience as much as does hand polishing, since he is able to process various types of samples simultaneously and observe the action of various cloths and abrasives.

There are no apparent reasons why vibratory polishing cannot be used in remote facilities. The machines are rugged; ours have required only routine maintenance, after the original adjustments, in the 14 months of practically continuous daytime operation. The polishers do not require mounted specimens of close tolerances, as do most facilities, and with simple precautions (such as substituting silicone oils or petroleum oils for water in the abrasive slurries) radioactive dust contamination should offer no additional problem. The controls for the polishers can be located outside the hot cells.

We feel that vibratory polishing has proven itself in our laboratory.

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Personal Mention

W. J. Reagan

A. F. Finkl

W. J. REAGAN has retired as associate professor of metallurgy at Pennsylvania State University. In the past, he has acted as consultant for many companies in the metals field, and after his retirement he will expand his consulting activities in this area.

He became a faculty member at Penn State in 1946 as assistant professor of metallurgy, specializing in extractive metallurgy and primary processing of iron and steel. He was responsible for building the unusually complete melting laboratory in the school of metallurgy.

Mr. Reagan's metallurgical education was obtained at Carnegie Institute of Technology and in industry, working in several steelmaking companies. He joined Edgewater Steel Co. in 1925 and spent 18 years there, rising to openhearth metallurgist and assistant superintendent of openhearth. In 1943 he moved to Warren, Ohio, as research engineer with Copperweld Steel Co., and later was promoted to superintendent of metallurgy.

Many technical societies claim his interest and he has been a charter member of several. These include the National Open Hearth Committee, Pittsburgh Conference, and the National Electric Furnace Conference. He is a 25-year member of the American Society for Metals and has served as chairman of the Pittsburgh Chapter (1937-38) and the Warren Chapter (1943-44).

A. F. FINKL has been appointed vice-president in charge of national sales for A. Finkl & Sons, Co., Chicago.

A native of Chicago, he attended the University of Illinois, graduating in 1931 with a Bachelor of Science degree. After five years with the metallurgical department of Republic Steel Corp., he became affiliated with A. Finkl & Sons, a family concern. He served in the metallurgical department until 1941 and from that time until the present he held positions in purchasing, advertising and quality control.

A. I. Nussbaum has been appointed vice-president of Loma Machine Mfg. Co., Inc, and its affiliate company, Lobeck Casting Processes, Inc., New York. Mr. Nussbaum joined Loma in 1956 as manager of the firm's rolling mill division, having previously held a similar position with Stanat Mfg. Co.

Gordon Moline has been appointed national sales manager of Metallurgical, Inc., Minneapolis. Mr. Moline, who was assistant engineer of Metallurgical's Kansas City, Mo., plant, has been with the company for four years.

Irwin A. Binder, vice-president, manufacturing, of the Ramo-Wooldridge Corp., Los Angeles, will have direct responsibility both in Denver and Los Angeles for the activities of the manufacturing division.

William A. Beck has been transferred to the Cleveland sales offices of the Dow Chemical Co. as a magnesium sales representative in Ohio and a field technical service representative for the Cleveland, Buffalo, Pittsburgh and Cincinnati sales offices. He was formerly a member of the magnesium technical service and development group of the magnesium department of Dow in Midland, Mich.

Robert W. Turnbull has accepted a position as research engineer for the Fram Corp. in Providence, R.I. He was formerly chief metallurgist for Fenn Mfg. Co. in Newington, Conn.

Gerald R. Kilp received a Ph.D. from Iowa State College, with a physical metallurgy major, and is now working at the Westinghouse Electric Co. atomic power department, Pittsburgh.

Fritz V. Lenel, a professor in the Dept. of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y., has received an Award of Merit for outstanding services from the American Society for Testing Materials.

John E. Dorn, **Thomas A. Trozera** and **Oleg D. Sherby** were presented with the Charles B. Dudley Medal in June by the A.S.T.M. in Boston for their paper entitled, "The Effects of Creep Stress Histories at High Temperatures on the Creep of Aluminum Alloys". Dr. Dorn is professor of physical metallurgy at the University of California while Mr. Trozera is coordinator of the cooperative engineering program of the College of Engineering, University of California, Berkeley, where he is studying for his doctorate. Dr. Sherby, formerly a research engineer at the Institute of Engineering Research of the University of California and later assigned to the Office of Naval Research, is now associate professor of metallurgical engineering in the Dept. of Metallurgical Engineering at Stanford University in California.

Kenneth B. Woods, head of the School of Civil Engineering and director, Joint Highway Research Project, Purdue University, was elected president of the American Society for Testing Materials at the Society's annual meeting in Boston.

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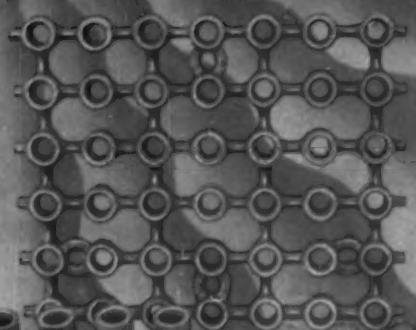

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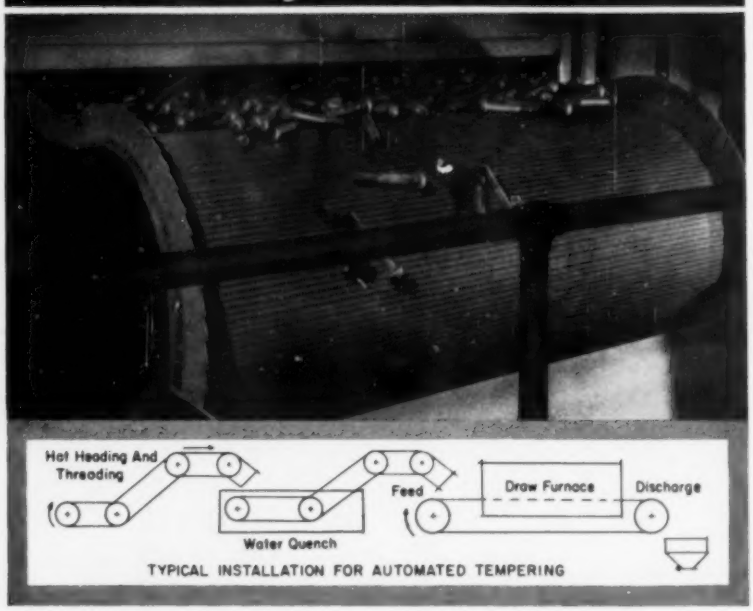

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Personals . . .

A. Allan Bates, vice-president of research and development, Portland Cement Assoc., was chosen vice-president, A.S.T.M. Elected for three years on the Board of directors were **Paul A. Archibald**, chief metallurgist at Standard Steel Works Div. of Baldwin - Lima - Hamilton Corp., and **William L. Fink** chief, physical metallurgy division, Alcoa Research Laboratories.

Jack L. White has been appointed staff member of the John Jay Hopkins Laboratory for Pure and Applied Science, General Atomic Div. of General Dynamics Corp., San Diego. He was formerly a research associate in the metallurgy division of the Naval Research Laboratory, Washington, D.C.

John DeMoss, formerly with the University of Notre Dame and the Keystone Carbon Co., has transferred within the General Electric Co. from the Small Aircraft Engine Dept., Lynn, Mass., to the Missile and Ordnance Systems Dept., Pittsfield, Mass.

George Mayer is serving his tour of duty in the Air Force at Tinker Air Force Base in Oklahoma City, Okla. He was formerly connected with Allied Research Associates, Inc., of Boston, as a research engineer and with the Chrysler Corp. missile division in Warren, Mich., as development engineer.

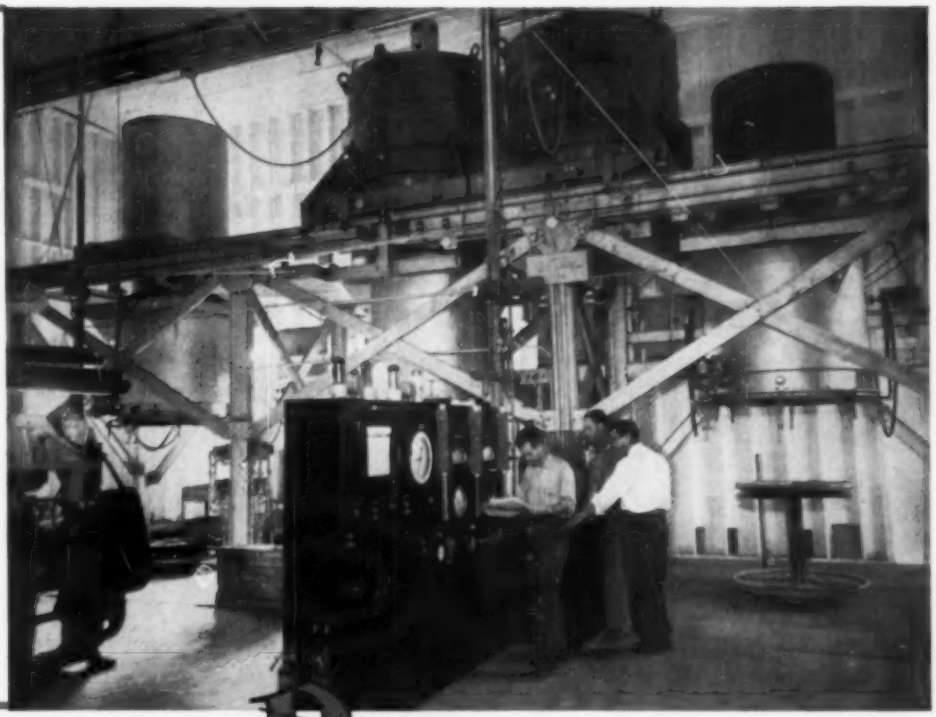
Victor Skvara has accepted a position with Martin Co. of Orlando, Fla. He was formerly with Hamilton Standard Div., United Aircraft Corp., Windsor Locks, Conn.

Gerald X. Diamond is now metallurgical consultant in Madison, Wis., continuing graduate studies toward an advanced degree in history of science.

Frank J. Pryatel has been transferred from the Cleveland Crawler Tractor Plant of the Oliver Corp., where he had been superintendent of methods and standards, to the Outboard Motor Div. in Battle Creek, Mich., as plant manager.

K. W. Tantlinger has accepted the position of vice-president of engineering for Fruehauf. He was formerly vice-president engineering for Pan Atlantic Steamship Corp.

here's a furnace with a brain!



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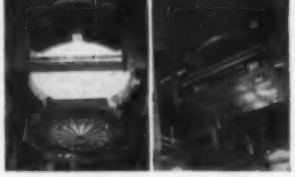

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Personals . . .

William R. Milliken, a veteran of 19 years' experience in metallurgy and sales with U. S. Steel Corp., has been appointed manager of stainless bar and wire sales by Universal-Cyclops Steel Corp., Bridgeville, Pa.

Don R. Knuebel recently joined Power Equipment Co., Pittsburgh. He was formerly with E. F. Houghton Co. as a sales engineer.

Henry M. Heyn has been elected president of Surface Combustion Corp. and president of the Surface industrial division, Toledo, Ohio. Mr. Heyn was formerly vice-president and general manager of the industrial division.

Ralph E. Herzler, Jr., has been appointed aluminum specialist for Chase Brass & Copper Co., a subsidiary of Kennecott Copper Corp. He will make his headquarters in Chicago.

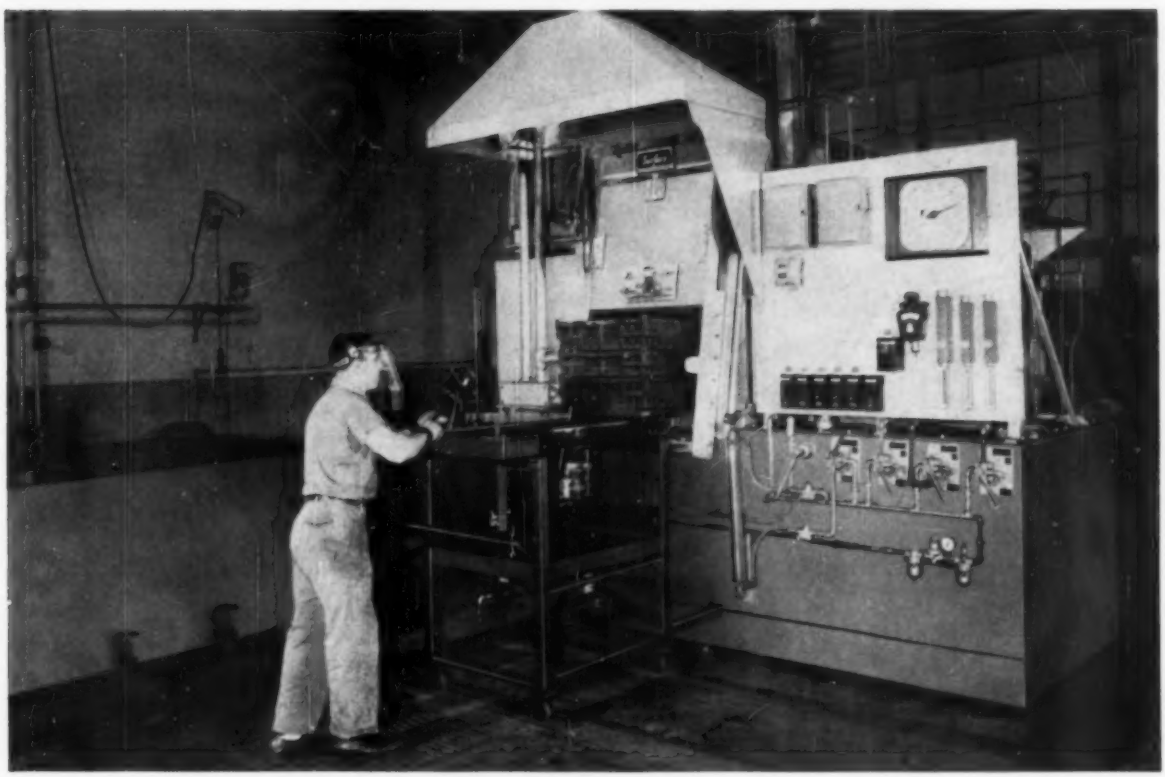
James C. Mourkas, formerly assistant to the manager of the tin mill products division of the Jones & Laughlin Steel Corp., Pittsburgh, has become assistant manager of the division. Mr. Mourkas joined the Jones & Laughlin sales training program in 1952 after his graduation from Yale.

E. H. Platz, Jr., Lebanon Steel Foundry, Lebanon, Pa., has been elected to the Board of Directors of the Alloy Casting Institute, Mineola, N.Y. **E. A. Schoefer** was re-elected executive vice president and treasurer of the Institute.

Hugo E. Johnson has been elected president of the American Iron Ore Assoc., Cleveland. Mr. Johnson has been with the association since 1954, and prior to that was assistant manager of the project development group at Battelle Memorial Institute, Columbus, Ohio.

R. L. Pope has been appointed district manager in Cleveland of the Electro Metallurgical Co., New York. Mr. Pope joined Electromet in 1952 as a metallurgical service and development engineer in Chicago, transferring to the New York office in 1954. In 1956, he was appointed assistant manager, marketing research division.

Allcase® furnace clips cost ½ on manicuring implements



One man and one furnace now match the former production of two men and two furnaces in this plant. Added to this gain are two others: greater versatility in processing, and finished work of uniformly high quality. The latter is especially important to this manufacturer of manicuring implements, because he offers a lifetime guarantee on many of his products.

The "hero" of this story is the Surface Allcase® furnace, which is used for hardening, carbonitriding, carburizing, and annealing. Controlled atmosphere is supplied by a Surface MRX® gas generator. Work handling and atmosphere control can be completely automatic, if you wish. Why don't you find out about this profitable furnace now?

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Personals . . .

Craig S. Hartley, after receiving a bachelor's degree in metallurgical engineering from Rensselaer Polytechnic Institute, accepted a post as staff metallurgist, fundamental metallurgy group, Nuclear Metals, Inc., Cambridge, Mass.

Steve S. Kozich has accepted the position of heading subcontractor, quality control and receiving inspection, at the liquid rocket plant of Aerojet-General Corp., Sacramento, Calif.

Kenneth Futernick recently organized K & F Metal Products Co., a brass and aluminum foundry.

Dominick C. Zaccone has accepted a position with the Pratt & Whitney Aircraft Research and Development Center, West Palm Beach, Fla., as materials test engineer. He was previously with the aircraft engineer division, Ford Motor Co.

J. Weertman is now a scientific liasion officer for the Office of Naval Research, London, covering the field of metallurgy.

R. P. Lutz has been named director of the Western Electric Engineering Research Center near Princeton, N. J. He was formerly vice-president of operations of the Sandia Corp. in Albuquerque, N. M.

During the Third Seminar on Powder Metallurgy held in Reutte, Austria, in June, a general meeting of the International Plansee Society was held at which **Henry H. Hausner**, vice-president, nuclear engineering division of the Penn-Texas Corp. of New York, was appointed president and **Ivor Jenkins**, chief metallurgist for the General Electric Co. Ltd. of England, was appointed vice-president. The Plansee Medal was awarded to Prof. **Franz Skaupy** for his outstanding contributions to powder metallurgy and related fields.

Daniel F. Heintz and **Paul S. Danilov**, sales trainees of Sharon Steel Corp., Sharon, Pa., have received sales assignments in the company. Mr. Heintz has been assigned to the market research division while Mr. Danilov will be a sales representative in the Sharon district sales office.

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AGENTS

MINNEAPOLIS—Industrial Electro-Gas Equip. Co., Phone: ATlantic 1907
HOUSTON—M. K. Griggs Co., Phone: CApitol 8-2261—7-5523
DALLAS—M. K. Griggs Co., Phone: WHithall 1-4994
TULSA—Kimball Chemical Co., Phone: Gibson 7-0168
KANSAS CITY—Industrial Electro. Gas Equip. Co., Phone: BE 1-3317

REPRESENTATIVES

DETROIT—C. R. Foreman, W. P. Askew, L. S. Woodside
CLEVELAND—R. W. Cameron, 19106 Southgate Road, Phone: LOngacre 1-8072
CHICAGO—M. J. Vandenberg, 2008 W. 102nd Street, Phone: CEdarcrest 3-7135
EAST LANSING, MICH.—R. Hammerstein, 1015 Northlawn, Phone: EDgewood 2-3926
CINCINNATI—James F. Hetz, 1313 Mimosa Lane, Phone: GRandview 1-3145
LYNNFIELD CENTER, MASS.—R. H. Settles, 651 Lowell St., Phone: 4-3390
PHILADELPHIA—T. J. Clark, 7240 Lawndale St., Phone: PIlgrim 5-6562

BURRELL *"For Scientists Everywhere"*

LABORATORY TUBE FURNACES

For carbons and sulfurs at high temperatures

Newest, most advanced design for fast determination of carbon and sulfur by combustion in all ferrous metals.

Burrell Tube Furnaces operate at the highest temperatures possible with silicon carbide elements.

Drawer-Type Panels for Ease of Access

Instrument panels pull out for ease of inspection, parts replacement and servicing when necessary. All electric components are mounted on the easy-access panel.

Cat. No.	FURNACE	Price
24-934	One-Tube Furnace, Model H-1-9	675.00
24-944	Two-Tube Furnace, Model H-2-9	700.00
24-954	Four-Tube Furnace, Model H-4-9	1000.00

For use with 115 or 230 volts, 60 cycle, as specified.
Prices listed are F.O.B. Pittsburgh, Pa.

Ask for Bulletin No. 310

BURRELL CORPORATION

Scientific Apparatus and Laboratory Supplies

2223 FIFTH AVENUE, PITTSBURGH 19, PA.

Personals . . .

Paul M. Cohen, formerly associated with the Westinghouse Electric Corp. metals plant at Blairsville, Pa., as development metallurgist, is now metallurgist in charge of engineering services at Beryllium Corp. in Reading, Pa.

Henry E. Ott, formerly manager of the materials and process laboratory of the air conditioning department of General Electric Co., Bloomfield, N. J., is now manager of Modern Metal Industries of New Jersey, Inc., Verona, N. J.

Fred Spiegl has been elected president of the Board of Directors of Titanium Fabricators Inc., Burbank, Calif. Mr. Spiegl was the founder of the company and former executive vice-president.

Robert J. Bradley has joined Plastic Horizons, Patterson, N. J., as chief engineer after serving for three years as consulting engineer.

Glenn F. Whiteley has been appointed manager of the Indianapolis plant of Heppenstall Co., Pittsburgh. Mr. Whiteley started with the company as a metallurgist at its Bridgeport, Conn., plant and was promoted to chief metallurgist there in 1944. He was transferred to Indianapolis in the same capacity in 1955.

Joseph H. Brennen, chief metallurgist of the Electro Metallurgical Co., Niagara Falls, N. Y., has been named as recipient of the Frank J. Tone Medal Award. The medal, awarded annually by the Niagara Frontier Section of the A.I.M.E. to an outstanding contributor to science and practical metallurgy, will be presented to Mr. Brennen at the annual award meeting in November.

Arthur E. Bayce has assumed duties as a metallurgist in the materials engineering and corrosion department of the Shell Development Co., Emeryville, Calif.

Lester A. Shea, who has been associated with Lindberg for more than 20 years, has accepted the position of district sales manager of the Pennsylvania office of the Lindberg Engineering Co., with headquarters in Pittsburgh.

SWIFT'S FLEXAL 2

THIS "LIGHT" METALLIC STEARATE WAS THE *MISSING LINK* IN AN IMPORTANT DEVELOPMENT

Your process might be the next to benefit

Until recently, Flexal² was the elusive *missing link* in a Swift research program aimed at the development of a superior and highly heat resistant water insoluble metal processing lubricant.

Flexal² is a "light" metallic powder of extremely uniform consistency. It has exhibited excellent heat stability and has shown long, effective and *economical* service life as an anti-friction agent for the processing of ferrous metals.

Swift's success with this program has revealed a *variety* of usages for Flexal² which has led to the development of a whole *family* of Flexals. The combination and range of physical and chemical properties offered by this new family of products will be of interest to anyone seeking a: *colloidal agent • stabilizer • process lubricant • parting agent • high speed and anti-friction compound • carrier • plastic additive • extender—and many other uses.*

The Flexals are available in production quantities or on sample or trial order. The benefit of Swift's technical experience with these remarkable products is available to help you. Just write for details. Swift & Company, Soap Dept., 4115 Packers Ave., Chicago 9, Illinois.

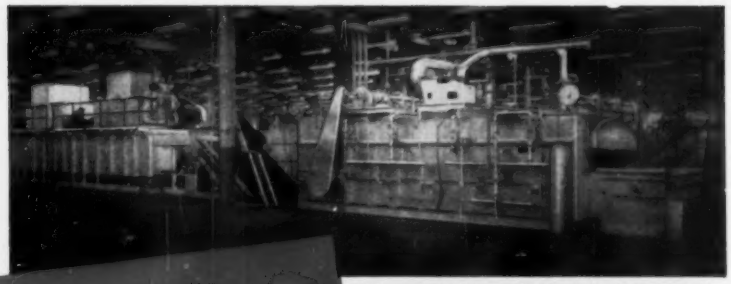
GENERAL PROPERTIES:

CHEMICAL	PHYSICAL
moisture—from 1% to 3% max.	form—amorphous to powder
titer range—10° C to 60° C	color—gray to white
iodine number—3% max to 95	odor—neutral
melting point—150° F to 800° + F	solubility—versatile; Flexals can be either soluble or insoluble in water or solvents, depending upon need.
storage life—completely stable	
molec. weight—(approx.) 288 to 700	

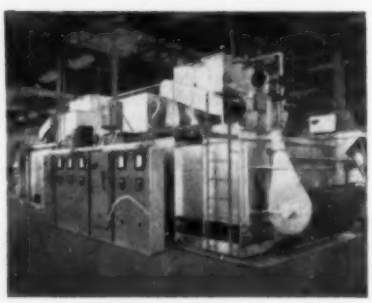
Swift

103 RD YEAR

To Serve Your Industry Better



...in Automated Harden Quench and Draw



A large automotive plant required furnaces to heat treat 4,000 lbs. per hour of forgings or castings automatically. The equipment had to be durable to produce a constant uninterrupted flow of parts and also effect a substantial saving over previous methods.

Industrial's direct fired continuous belt type hardening furnace and famous "CIRC-AIR" draw are doing the job. Loading 35 lbs. per square foot of conveyor, hardening is at 1700 deg. F., quench in 1700 gallons of oil and temper at 1200 deg. F.

The rugged, dependable Industrial furnaces are completely automatic; produce 4,000 lbs. per hour every hour every day.

Besides saving man hours, there is a 20% fuel saving by use of the continuous belt conveyor operating wholly within the hardening furnace.

Industrial's "CIRC-AIR" draw furnace is the most efficient heating machine made for temperatures up to 1300 deg. F. High velocity fans force recirculated hot gases through the work with no temperature head. Thin and thick sections come to heat evenly; and the entire load is heated uniformly.

Send for "CIRC-AIR" Bulletin No. 13-A

SEE US AT BOOTH No. 1035
NATIONAL METAL SHOW

CIRC-AIR

INDUSTRIAL
HEATING EQUIPMENT CO.

3570 FREMONT PLACE, DETROIT 7, MICHIGAN • WALNUT 3-7000

PIONEERS AND STILL LEADERS IN RECIRCULATION

Personals . . .

R. C. Rhoades, formerly superintendent of Bolt & Forged Products, has been appointed works manager of the Kansas City Works of the Armco Steel Corp.

Albert J. Woods has been named Buffalo, N.Y., district manager of the Latrobe Steel Co.

G. H. Weight, formerly Southwest district sales manager of Babcock & Wilcox Co. tubular products division, has been made sales manager, middle states, with headquarters in Chicago. He joined the company in 1926 and entered the sales department in 1935.

Gregory R. Taylor has been appointed sales manager of the new Cold-Prest Impact Extrusion Div., Mueller Brass Co., Port Huron, Mich. A sales engineer for the past eight years, Mr. Taylor has been affiliated with the Weatherhead Co. and the Townsend Co.

Richard Hayden, formerly head of the industrial furnace division of Eclipse Fuel Engineering, Rockford, Ill., will have charge of gas furnace sales at Hevi-Duty Electric Co., Milwaukee. Eclipse's industrial furnace division was recently acquired by Hevi-Duty.

Herbert E. McCoy, formerly at the University of Tennessee and **Sidney G. Nelson**, until recently at Pennsylvania State University, were appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn.

E. N. Smith has been named technical director of the Kennametal Inc. chemical and metallurgical laboratory in Latrobe, Pa. He has been associated with Kennametal Inc. since 1945.

Charles W. Sinclair has been appointed vice president, engineering, for all divisions of the Kelsey-Hayes Co., Detroit. Connected with Kelsey-Hayes since 1911, Mr. Sinclair previously had served as chief engineer for the automotive division.

Winston R. Seetoo has been promoted from test engineer to testing supervisor for Metals Research and Development, Inc., Exeter, Pa.

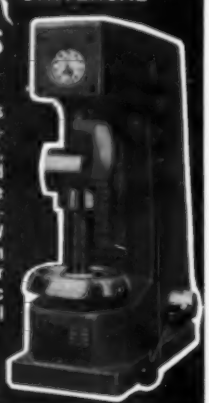
Metal Progress

Bulletin Board...

The Buyers Guide For Metals Engineers

Frank UNIVERSAL HARDNESS TESTER

It combines tests for Rockwell B and C, Brinell and Vickers in one low-priced machine with NEW push-button load-selector and automatic zeroing for dial gage.



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OPTO-METRIC TOOLS, INC.

137 MP VARICK STREET, NEW YORK 13.

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BARGAINS YOU CAN TRUST

Priced to Save You 50% and More!

ORDER BY STOCK NUMBER . . . Open Account or send check or money order. We guarantee complete satisfaction or money back!

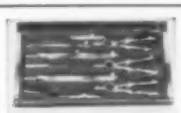
Erect Image

Low Power Microscope

5X, 10X, 20X

Extremely sturdy with rack and pinion focusing, color corrected optics, turretable microscope body for inclined viewing, three different powers, long working distance under objectives, sufficient eye relief for easy viewing. Made from war surplus optical instrument so that you actually get $80.00 of value. Weighs 4 lbs., 12" high. 10 DAY FREE TRIAL! Accessory objectives available for powers of 15X, 30X, 40X.

Stock No. 70,172-HA.....$19.95 Postpaid



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Regular Price $18.00

Our Price Only $6.00 Pstpd.

10 handsome pieces in velvet-lined case. Nickel plated brass—precision American-made. Set contains 5½" Swedish Ruling Pen, 5½" Compass, lengthening Bar for Compass 3¼", Interchangeable Pen for Compass, 5½" Dividers with straightening device, Center Wheel 3" Bow Pen, Center Wheel 3" Bow Pencil, Center Wheel 3" Bow Divider, Adjusting Screw Driver, Spare Parts Container with Leads and Points. We guarantee you will be satisfied or money refunded.

Stock No. 50,200-HA $6.00 Postpaid

Quantity Price: 5 Sets for $5.50 each Postpaid
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Save with ULTRASONIC CLEANING EQUIPMENT by acoustica ASSOCIATES, INC.

*PAID FOR ITSELF QUICKLY

Otis engineers report that the Acoustica DR400 Ultrasonic cleaning unit "paid for itself in the first six months operation... reduction of hand labor operations... resulted in a savings in the ultimate manufacturing costs."

Photographed at Otis Elevator Company, Electronic Division

The electronic chassis frames and sub-assemblies are immersed and cleaned of excess solder and solder flux in a fraction of the time previously required.

Write for "Building Blocks for Industry"

*LETTER ON FILE.

acoustica ASSOCIATES, INC. 23 Windsor Ave. • Mineola, N. Y., Pioneer 7-7900
11517 W. Jefferson Blvd. • Culver City, Calif.

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The ideal gift for a metals man is a copy of . . .

MAN, METALS AND MODERN MAGIC

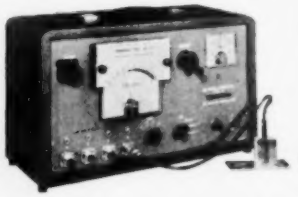
An ASM book of interest to both the expert and the student. The exciting story of the progress of metals. What metals mean to man.

$2.95

Order your copy from ASM Headquarters in Cleveland. Postage paid.

THE NEW
DERMITRON

NON-DESTRUCTIVE
COATING THICKNESS TESTER



FAST... ACCURATE
NON-DESTRUCTIVE
DIRECT-READING

- Instantly measures the thickness of metallic and non-metallic coatings and films
- Based on eddy-current principles
- Enables measurements on small or otherwise inaccessible areas

This portable instrument for both laboratory and production use, gives fast, accurate and direct readings of virtually any coating on any base, including:

- Metal coatings (such as plating) on metal base (magnetic and non-magnetic)
- Non-metallic coatings (such as paint, anodizing, hard-coat, ceramic) on metal base
- Metal films (such as vacuum metalizing) on non-metallic base (plastics, ceramics)

MEASURING PROBES ARE AVAILABLE IN THE THREE TYPES SHOWN BELOW

NEW RIGHT-ANGLE PROBE model "RP" enables measurements in holes down to ½" I.D.

STANDARD PROBE model "SP" enables measurements on convex surfaces down to ⅛" radius of curvature and on concave surfaces down to 2" radius of curvature

MODIFIED STANDARD PROBE model "MP" enables measurements on concave surfaces down to ¼" radius of curvature

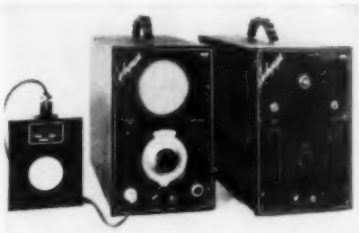
Each of the above probe types is available in 4 different thickness ranges—A, B, C and D, from thick to thin deposits.

Write for latest bulletins and questionnaire to help solve your thickness testing problems

UNIT PROCESS ASSEMBLIES, INC.

LIST NO. 139 ON INFO-COUPON PAGE 171

DICE
does it better!



THE CYCLOGRAPH, (Model C)

. . . for unscrambling metal mixups

This instrument permits truly high speed, non-destructive sorting of raw, semi-finished or finished parts by their metallurgical characteristics. With the new Automatic Sorter Unit, speeds up to 300 pieces per minute are possible with the use of suitable feeding equipment. Used by leading industrial firms everywhere.

J. W. DICE CO.

"Non-destructive Testing and Measuring Instruments"
Englewood 3 New Jersey

In Canada: Non-Destructive Testing Corp., Ltd., Toronto

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Metallizing Wires

Rigidly Specified for Metal Spraying

Spra-Rod
Corporation
2795 East 83rd St., Cleveland 4, Ohio

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TENSILKUT

Tensile and fatigue test specimens can be accurately machined from foil metals as light as .0005" or heavy .500" plate in less than two minutes. Machined edges are completely free of cold working and the specimen configurations are duplicated within ± .0005".

TensilkuT machines a wide range of metals including steel, aluminium, stainless steel, copper, titanium, uranium, lead, the super alloys and all plastic materials.

Tensilkut table and floor models are available with motors from ½ to 2½ HP. Write for our latest brochure.

Trade Mark Registered U.S. Patent Office Patents Pending United States & Canada.

SIEBURG INDUSTRIES
INCORPORATED
HORSE PLAIN ROAD • NEW BRITAIN, CONN.

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HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.

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Inspect
NON-FERROUS–NON-MAGNETIC
Metals . . .

with Magnetic Analysis MULTI-FREQUENCY EQUIPMENT. An eddy current tester with six inspection methods operating simultaneously — for high-speed, non-destructive testing of non-ferrous and non-magnetic tubing, bars and wire from ⅛" to 3" diameter. Detects both surface and sub-surface flaws, and variations in chemical, physical and metallurgical properties at speeds of 200 to 600 ft./min.

"THE TEST TELLS"
For Details Write:
MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 193 ON INFO-COUPON PAGE 171

ULTRASONIC
Thickness Testing from One Side

Rapid, Accurate, Non-Destructive

VIDIGAGE®

14" or 21" Cathode-Ray Screen with direct-reading scales between 0.005" and 2.5"; accuracy 0.1% to 1.0%.

AUDIGAGE®

Portable Thickness Testers for ranges from 0.020" to 4" or 0.060" to 12" of steel; accuracy up to 1.0%.

Detect Laminar Flaws and Lack of Bond

BRANSON INSTRUMENTS, INC.
6 Brown House Rd., Stamford, Connecticut

Specializing in Ultrasonics Since 1946

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make hardness tests ANYWHERE WITH THE **NEWAGE TESTER**

- CLAMPS, JAWS & BASE PLATE ARE ELIMINATED
- NO CONVERSIONS OR CALCULATIONS
- TEST ANY SIZE, SHAPE OR TYPE METAL
- NO SKILL REQUIRED
- SCALE READINGS IN ROCKWELL & BRINELL
- ACCURACY GUARANTEED

Many thousands used by industry and government. Write, wire or call for additional details and prices.

NEWAGE INDUSTRIES, INC.
222 York Road, Jenkintown, Pennsylvania
TUrner 4-8494 Dept. MP

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KENTRON
MICRO HARDNESS TESTER

Applies 1 to 10,000 gram loads
Write for Bulletin

Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

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NEW pocket-size THICKNESS GAUGE

For flat or curved surfaces

only **$75.00** F. O. B. Cleveland

Measures Nonmagnetic Coatings with ±5% ±.0001" accuracy

ELCOMETER measures thickness of porcelain enamel, paints, platings, foils, glass, paper, plastics, and other nonmagnetic coatings quickly and accurately. Gauges flat or curved surfaces and hard-to-get-at spots easily. Needle locking device assures correct reading every time. Complete with leather case containing inner pocket for test strips. Weighs only 6 oz. Completely self-contained.

WRITE FOR ILLUSTRATED FOLDER

FERRO CORPORATION
4155 East 56th Street
Cleveland 5, Ohio

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Solve
Inspection Sorting Demagnetizing *Problems*
with
MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed — 120 ft. per minute.

SPECIAL EQUIPMENT

Electronic equipment for non-destructive production inspection of non-ferrous bars and tubing . . . as well as both non-magnetic stainless and high temperature steel bars and tubing — seamless or welded. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed — 200 ft. per minute.

WIRE ROPE EQUIPMENT

Electronic equipment for inspecting ferromagnetic wire ropes from 1/32" to 3" diameter. Detects broken, cross-over or missing wires, plus defective welds and deformations at production speeds up to several hundred feet per minute.

COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

DEMAGNETIZERS

Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

"THE TEST TELLS"

For Details Write:

MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.

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GOOD USED EQUIPMENT AT REAL SAVINGS TO YOU!

2—Like-new roller hearth furnaces! Surface Combustion recirculating ovens for tempering or aluminum treating. Inside work dimensions: 49 in. wide x 17½ ft. long x 26 in. high.

Gas-fired for 1200° F. Complete with automatic doors and fast discharge mechanism, two recirculating fans with 15 hp. (220/440/3) motors, turbocompressor, safety equipment, and Brown Electronik strip chart recorders.

1—Same as above except 45 ft. long. Bricklined.

METAL TREATING EQUIPMENT EXCHANGE, INC.
9825 GREELEY ROAD
DETROIT 11, MICHIGAN

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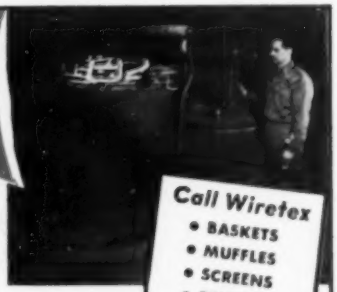
JELLIFF HEAT-TREATING BASKETS

All shapes, sizes, alloys.
Estimates without obligation.

THE C. O. JELLIFF MANUFACTURING CORP.
SOUTHPORT, CONNECTICUT

LIST NO. 91 ON INFO-COUPON PAGE 171

WIRETEX Pit Furnace ASSEMBLY



cuts treating time 50%
lowers labor costs 66%

A well known foundry customer* substituted **WIRETEX** Inconel baskets and frames for cast iron pots and carriers for their pit type heat treating furnaces and discovered a way to save hundreds of dollars in labor, materials, maintenance and replacements. Best of all . . . production skyrocketed!
WIRETEX engineered baskets can do the same for you—it'll pay to investigate!

Specialists in processing carriers since 1932

Wiretex 5 Mason St., Bridgeport 5, Conn.

*Actual case history story, photos and WIRETEX catalog, free for asking. Write today!

Call Wiretex
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- MUFFLES
- SCREENS
- RETORTS
- TRAYS
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to resist acids, heat, abrasion or exposure. Small, large—standard or custom made in every weave, metal and alloy.

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309 St. Louis Ave.
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William McAtee
626 N. DeQuincy St.
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There's a STANWOOD Heat Treating Equipment Sales Engineer as near as your phone!

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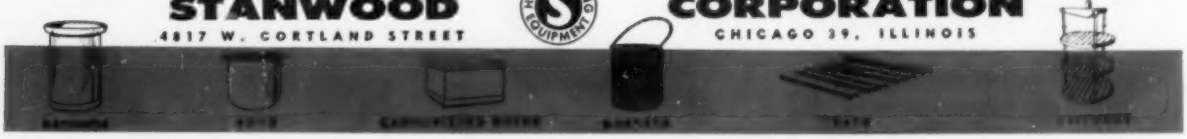

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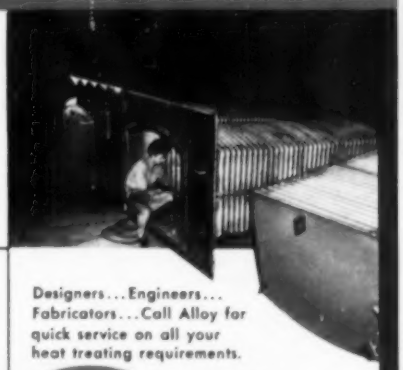
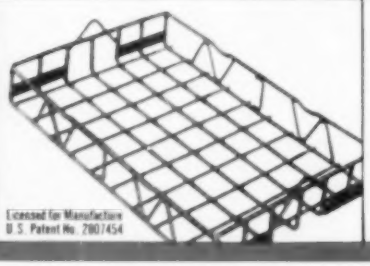
ALLOY ENGINEERED RETORTS & BASKETS

Engineering answers and highest quality manufacturing . . . developed by years of alloy specialization.





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Designers . . . Engineers . . . Fabricators . . . Call Alloy for quick service on all your heat treating requirements.

ALLOY ENGINEERING CO.

74 SHELDON ROAD
BEREA, OHIO

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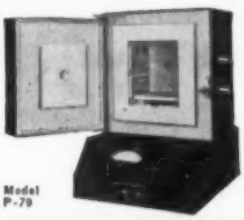
PRODUCED AND PRICED RIGHT FOR YOUR ELECTRIC FURNACE NEEDS

DYNA-TROL

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (300° to 2000°)	PRICE (400° to 2300°)
P48	4½"x4½"x8"	$90.00	$110.00
P79	9"x9"x9"	$205.00	$225.00
P918	9"x9"x18"	$480.00	$528.00
P414	14"x14"x14"	$525.00	$603.25
P124	12"x12"x24"	$715.00	$822.25
P818	18"x18"x18"	$775.00	$887.50
P138	18"x18"x36"	$1125.00	$1312.50

Automatic Controls Available on all Models



Model P-79

- Infinite zone temperature control
- Zone temperature indication by Pyrometer Selector Switch
- Automatic hold and cut-off instrument available
- Patented element holders
- Infinite variety of time-temperature curves obtainable
- Rugged construction

"ATMO-CARB" MODEL MHE-458 Complete with Carburizing Atmosphere Generator and Automatic Control

$1325.00

Other Sizes and Arrangements Available

MANUFACTURING CO.
Chester 77, Pa.

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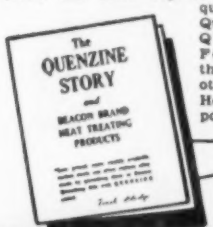
FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



KELCo

ALDRIDGE INDUSTRIAL OILS, Inc.

3491 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 171

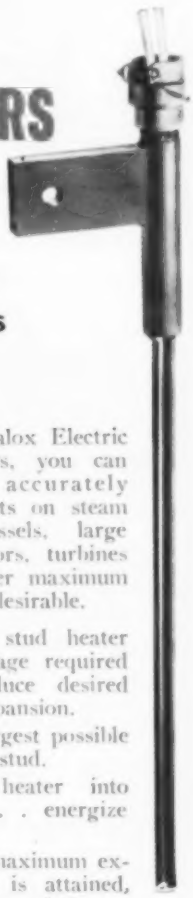
END POT FAILURE

Switch to *scheduled* pot maintenance with low-cost pressed-steel pots for lead, salt, cyanide, oil-tempering, metal-melting. Can't turn suddenly defective, because no faulty steel survives drawing. Request catalog from Eclipse Fuel Engineering Co., 1127 Buchanan St., Rockford, Ill.

Eclipse INDUSTRIAL COMBUSTION DIVISION

LIST NO. 176 ON INFO-COUPON PAGE 171

NEW CHROMALOX STUD HEATERS



for shrink-tightening large studs and bolts

With Chromalox Electric Stud Heaters, you can easily and accurately shrink-fit bolts on steam pressure vessels, large presses, motors, turbines . . . wherever maximum tightness is desirable.

1. Choose stud heater of wattage required to produce desired stud expansion.
2. Drill largest possible hole in stud.
3. Insert heater into hole . . . energize heater.
4. When maximum expansion is attained, draw down bolt.
5. De-energize and remove heaters. Cooling and contraction draws down to desired tightness.

FREE! Send for new Bulletin L-1244. Contains detailed product description, illustrations of how to use, and table of Chromalox Stud Heater sizes, ratings and prices.

2626

CHROMALOX Electric Heat
INDUSTRIAL • COMMERCIAL • RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7799 THOMAS BLVD., PITTSBURGH 8, PA.

LIST NO. 191 ON INFO-COUPON PAGE 171

HEIL CORROSION PROOF EQUIPMENT

TANKS Pickling, Plating, Anodizing, Storage. Sheet Linings, Coatings, Steel and Alloy Construction.

ACID HEATING Nocordal (Impervious Graphite), Lead and Alloy Heat Exchange Units. Immersion and External Types.

VENTILATING EQUIPMENT Hoods, Fans, Ducts, Stacks, Scrubbers for Collecting and Removing Corrosive Fumes. Solid Plastic Lined Steel.

STEAM JET AGITATORS For Heating and Agitating Acid Solutions. Special Lead Alloy and Solid Impervious Graphite.

Also Baskets—Crates—Hairpin Hooks

Write for fully descriptive Bulletins

CHEMICAL-PROOF LININGS · TANKS HEATERS PLASTICS

HEIL PROCESS EQUIPMENT CORPORATION

12901 ELMWOOD AVENUE • CLEVELAND 11, OHIO

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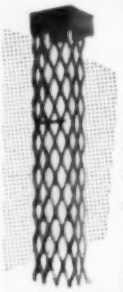
there's a *Glo*-QUARTZ* IMMERSION HEATER for Your Every Heating Requirement



- INSTANT HEATING
- SHOCK-PROOF
- AVAILABLE IN ALL VOLTAGES —WATTAGES, ONE AND THREE PHASE

Available from your Electroplating Distributor

WRITE FOR BULLETIN ▶

Glo-QUARTZ*

ELECTRIC HEATER CO., INC., Willoughby, Ohio

*Reg. U.S. Pat Off. Phone Willoughby 2-5521

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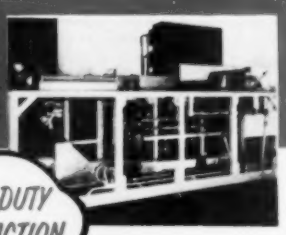
EVERY PITTSBURGH INDUCTION HEATING FURNACE installation is backed by these outstanding features:



- Pre-testing of Unit
- One-Year Warranty
- Maximum Safety
- Labor and Space Savings
- Greater Margin of Profit

HEAVY-DUTY CONSTRUCTION

PIH

Consult a PIH Engineer for complete information on a wide range of applications for optimum heating of all metals for numerous metal working operations such as forging, rolling, annealing, extrusion, and others.

Write for detailed brochure with frequency chart

PITTSBURGH INDUCTION HEATING COMPANY INCORPORATED

615 Washington Road, Pittsburgh 28, Pa. Phone LO. 3-6020

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COMING IN JANUARY

TO MEET THE NEEDS OF METALS ENGINEERS AROUND THE WORLD

THE "INTERNATIONAL" ISSUE OF METAL PROGRESS

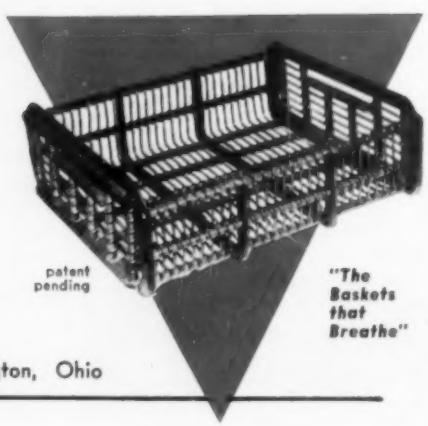
AN ENGINEERING FIRST IN BASKET FABRICATION

bixco HEAT TREAT BASKETS

These Job-Tested and Proved Designs Incorporate:

- SPECIAL LOOPED WIRE
- NON-WELDED SUPPORT RODS
- NON-WELDED FRAMING
- FLOATING INNER FRAMES

First and Only Baskets with All These Features



patent pending

"The Baskets that Breathe"

WRITE for NEW 1959 CATALOG with BIX COMPANY'S COMPLETE LINE of BASKETS and FIXTURES

bix **COMPANY** Fairgrounds Rd., Wellington, Ohio

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SURPLUS FURNACES FOR SALE

ATMOSPHERE GENERATORS
250 to 15,000 CFH Exo and Endo

BOX TYPE

24x36x18	Lindberg	50KW	2000°F
48x84x24	American	100KW	1850°F
24x36x14	Surface	Gas	1850°F
54x96x24	Surface	Gas	1850°F

PIT TYPE

20x22	G.E.	48KW	1200°F
48x60	Lindberg	90KW	1250°F
48x96	Surface	Gas	1250°F
48x96	Lee Wilson	Rad. Tube	1850°F

CONVEYOR TYPE RECIRCULATING

72x40'x30	Surface	RlrHrth Gas	1250°F
27x15'x12	R&S	MshBlt Gas	1250°F

BOX TYPE RECIRCULATING

6'x12'x42"	Lindberg	Gas	1250°F
66"x16'x76"	Lindberg	180KW	1250°F
60"x10'x42"	Lindberg	180KW	1250°F
42"x16'x30"	Lindberg	120KW	1250°F

BOX & CONVEYOR OVENS

6'x30'x18"	Mich Oven Conv	150KW	550°F
6'x30'x18"	Mich Oven Conv	150KW	400°F
5'x16'x12"	Mich Oven Conv	150KW	800°F
2'x2'x4'	Rockwell Box	5KW	550°F
7'x7'x7'	Young Bros Box	Gas	650°F
19"x19"x19"	Despatch Box	5KW	850°F

BRAZING TYPE

18"x42"x12"	Lindberg Pshr	60KW	2500°F
18"x42"x10"	Westinghouse Pshr	50KW	2050°F
62"x18'x24"	GE RlrHrth	655KW	1650°F

SEND FOR COMPLETE LIST

THE JOE MARTIN CO., INC.
19256 John R. St. TWinbrook 2-5500 Detroit 3, Mich.

WANTED

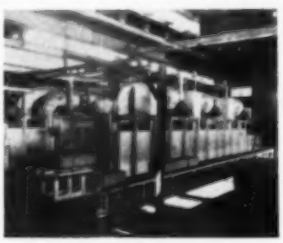
SURPLUS FURNACES

REWARD

WE PAY CASH FOR SURPLUS INDUSTRIAL FURNACES AND RELATED APPARATUS

LIST NO. 160 ON INFO-COUPON PAGE 171

PACIFIC FURNACES ARE ENGINEERED FROM THE INSIDE OUT



Pictured is a Pacific Air Draw Furnace currently drawing and tempering 3000 lb. of pearlitic malleable iron castings per hour at a leading foundry. This Pacific engineered furnace features hydraulic pushers, three-zone automatic cycling, and automatic unloading at the completion of the operation. It operates at 1400° F.

Pacific ENGINEERS . . . . BUILDS. . . . SERVICES all types of industrial heating equipment.

FOR COMPLETE INFORMATION ON OUR SERVICES —WRITE OR CALL

THE Pacific INDUSTRIAL FURNACE CO.
24680 Telegraph Road, Detroit 41, Michigan
Phone: Kenwood 7-4250

LIST NO. 173 ON INFO-COUPON PAGE 171

POT-TYPE SALT BATH FURNACE

The features listed below are but a few of the in-built advantages of the **LUCIFER 2055 SERIES.**

- Eliminates atmospheric problems (oxidation, scaling and decarburization)
- Rapid constant heat
- Choice of 10 models
- Heat ranges to 1,700° F.
- All controls included (automatic indicating controller, selector switch with two thermocouples)
- Quick easy installation
- Low initial cost . . . low upkeep
- Top production performance with unskilled labor
- Minimum replacement down-time

Lucifer Furnaces, Inc., manufactures many standard electric heat treating furnaces and maintains a design department to create special units. For engineering assistance, parts or product information write or call . . .

LUCIFER FURNACES, INC.
Neshaminy 7, Pennsylvania
Diamond 3-0411

BY LUCIFER FURNACES

LIST NO. 122 ON INFO-COUPON PAGE 171

---

don't hide it under a BUSHEL...

. . . if you have an idea in which you figure an aluminum extrusion will best solve a manufacturing problem involving a functional metal parts application. G.E.I.'s highly skilled engineering staff is eager and ready to discuss your idea with you, at no obligation, on one part or a million, to determine if your theory can be put to practical use. G.E.I.'s engineers specialize in adapting extruded aluminum to new functional roles—helping customers make extruded aluminum save time and money. G.E.I. is equipped to handle all aluminum processing services, including extruding, fabrication, anodizing, machining, etc.

GENERAL EXTRUSIONS, INC.
4040 Lake Park Road STerling 8-9681
YOUNGSTOWN, OHIO
Missouri, S. Illinois Representative:
Frank May Co., 4378 Lindell Blvd., St. Louis 8, Mo.
Michigan Representative:
Howard B. Jones, 15842 Kentfield Ave., Detroit 23, Mich.
Southern Representative:
Jack Widman, 1382 Poplar Ave., Memphis, Tenn.
W. C. Jones Distributing Co., 6450 Keyler Rd.
Cincinnati, (Rossmoyne) Ohio

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AMMONIA DISSOCIATORS

Drever 3000 CFH Units

60 KW, 3-phase, each with Brown 1500-33PS-21 and 105-C4PS-13, plus transformers and contactor.

Weight, 3000 lb. Operating temperature, 1750° F. Practically new.

Also other used units such as:

- ★ **Nitriding, Tempering**
- ★ **Rotary Carburizing Units**
- ★ **Salt Bath Units**
- ★ **plus other items**

The W. H. Kay Co.
4040 Mayfield Rd. Cleveland 21, Ohio
Phone, EVergreen 1-3440

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Sel-Rex®

PRECIOUS METALS FOR INDUSTRIAL PLATING

BRIGHT GOLD
Mirror-bright finish in any thickness directly from the bath. Patented

PUR-A-SALTS
Restores contaminated cyanide plating baths to full, trouble-free operation. Patented

SILVREX BRIGHT SILVER
Crystal-clear solution that produces mirror-bright deposits. Patented

SILVER SOL-U-SALT
Non-dusting—safest and easiest to use.

BRIGHT RHODIUM
Brilliant, fine-grained non-tarnishing deposits.

RHODEX
Only rhodium electroplating process that yields extra heavy compressively stressed deposits. Patent Pending

ACID GOLD PLATING PROCESS
Developed specifically for plating printed circuits. Mildly acid so that neither the laminate nor the adhesive at the inter-face of printed circuit boards are affected during the plating process.

Complete installation and servicing on all precious metals processes.

SEL-REX CORPORATION
Dept. BB, Nutley 10, New Jersey
Offices: Detroit, Chicago, Los Angeles

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SPECIAL SERVICE ON *HIGH SPEED* STEEL FORGINGS

FAST NATION-WIDE SERVICE ...YOUR STEEL OR OURS

Complete Source For Forged Products Up To 4000#
Rings, discs, spindles, bars or special shapes to your specifications.

28 Years Of Specialized Experience
In production of high speed tool and alloy steel flat die forgings.

Ample Stocks Of Steel Always On Hand

Expert High Speed Steel Blacksmiths

Call or write for free cost quotation on your forging requirements

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WRITE FOR GRAPHITE INFORMATION

CUSTOM MACHINED PARTS FOR SEMICONDUCTOR PROCESSING
Your custom requirements are available . . . matchlessly machined . . . high purity graphite for all phases of semiconductor processing: reduction and refining boats—crystal-pulling heaters and devices—fusion jigs and components.

PRODUCTS FOR SPECIAL METALLURGICAL APPLICATIONS
Complete range of stock sizes in rods, blocks and tubing available. Also, your custom requirements of specially machined articles can be promptly produced.

PREFORMED SHAPES FOR VACUUM FUSION ANALYSIS
Matched crucible and funnel combinations . . . powder and chips . . . all available from stock for immediate shipment.

SPECTROGRAPHIC ELECTRODES
Recognized as the standard of the world, United's rods, powders and wide range of preformed electrodes are available in the right sizes and designs for your spectrographic work.

Write Direct To:
UNITED CARBON PRODUCTS CO.
P. O. Box 269 • Bay City, Mich.

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Plan now to attend the 11th Western Metal Congress and Exposition in Los Angeles, California, March 16-20.

Look ahead . . . you'll want to participate in this regular Metal Show that has the metal industry's stamp of approval . . . always successful for the exhibitor! Plan to take part . . . don't wait!

Floor plans and descriptive literature can be obtained by writing to ASM Headquarters in Cleveland.
7301 Euclid Avenue.

Need Help Designing That Aluminum Extrusion?

TEAM UP with JARL

THERE'S A WORLD OF DIFFERENCE

The *difference* starts the moment you meet the Jarl salesman. He's an engineer . . . well qualified to make on-the-spot recommendations in designs. Team up with Jarl and you'll get the right shapes made to most exacting design specifications. You'll be sure of close die control . . . quality safeguards every step . . . on-time deliveries. Send for our stock die catalog or send rough sketches for assistance with your design.

ANODIZING

JARL EXTRUSIONS, INC.

Dept. MP, Linden Ave. • East Rochester, N. Y.

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GET A BID FROM

HOOVER

SPECIALISTS IN THE FIELD OF

Die Castings

SINCE 1922

Aluminum and Zinc

THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio
In Canada—Hamilton, Ontario

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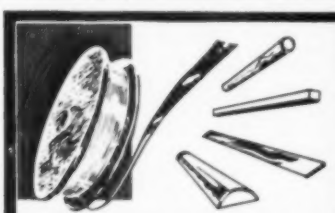

ROUND, SQUARE, FLAT AND HALF-ROUND WIRE FOR MASS PRODUCTION OF SMALL PARTS

Beryllium Copper • Bronzes
Other Non-ferrous Alloys
Rounded or square edges.
Available with hot-tinned finish for solderability.
Write for descriptive folder.

LFA **LITTLE FALLS ALLOYS**
INCORPORATED
193 Caldwell Ave., Paterson 1, N. J.

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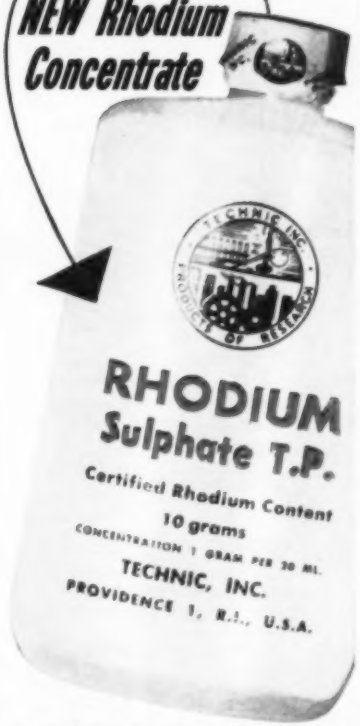
Test this NEW Rhodium Concentrate



an improvement by **TECHNIC**

Technic developed this superior Rhodium concentrate to meet today's electroplating specifications with —

- ✻ Lower Stress
- ✻ Higher Purity
- ✻ Finer Grain

Testing is easy because of high compatibility with existing Rhodium baths. Ask for complete data on characteristics and applications. When you adopt Technic solutions or methods, our technical staff is yours until optimum performance is assured. Write or phone today.

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39 Snow Street
Providence, R. I.
JAckson 1-4200
Chicago Office
7001 North Clark St.

TECHNIC, INC
PRODUCTS OF RESEARCH

355-8

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

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Whitelight MAGNESIUM

your comprehensive independent mill source of magnesium alloy . . .

ALLOYS
AZ10
AZ31
AZ51
AZ61
AZ81
ZK60
ZK30
M-1
ZK-20
Anodes

RODS ⅛" dia. to 6½" dia.
BARS, STRIPS .022" min. to 7½" max
SOLID SHAPES .022" min. to 6½" circle
TUBING ¼" O.D. to 6" O.D.
HOLLOW SHAPES ½" to 6½" circle
PLATE & SHEET .092" to 3" thick

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.

82 Moultrie Street, Brooklyn 22, N.Y.
Factories: Brooklyn, N.Y. • Warsaw, Ind.

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How Roll Coater

Pre-Painted

METAL SAVED MONEY AND IMPROVED QUALITY ON

R-C-000 LICENSE PLATES

PROBLEM:

Stello Products Company, Logansport, Indiana, manufacturer of tags, license and "booster" plates, had the problem of excessive direct labor charges. In the previous expensive method of making these items, plates had to be stamped from bare metal —and then cleaned individually—and spray painted on both sides. This method did not give the uniform quality demanded—and Stello turned to Roll Coater for a solution.

SOLUTION:

Roll-coated metal was tested by Stello Products Company. *Pre-painted* and *baked* on both sides, this metal eliminated *entirely* the cleaning and spray painting operations—withstood rigorous stamping tests—and relieved painting facilities for other jobs. Says J. C. Cotner, president of Stello Products Company, "Roll Coater metal is now saving us approximately 50% in direct labor costs—and is giving us the desired uniform quality in our plate production. It really solves our problem."

SEND FOR FREE BROCHURE and SAMPLE TODAY!

Roll Coater
INCORPORATED
PENDLETON, INDIANA

LIST NO. 155 ON INFO-COUPON PAGE 171

the GRIES
MICRO-REFLEX
HARDNESS TESTER

Loads: 10 to 3000 gram with CARL ZEISS Optical System

Measurement: to 0.0001 mm. . . . Observations on Ground Glass . . . Projection: to 0.001 mm. . . . Many Unique, Very Important Features.

INVESTIGATE!
Write for Bulletin No. A-16

GRIES INDUSTRIES, INC.
Testing Machines Division
NEW ROCHELLE 3, N. Y.

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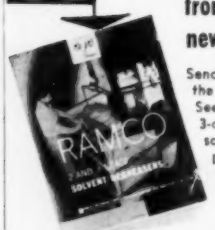
Q A METAL PARTS CLEANING PROBLEMS?

Get the answers RIGHT from RAMCO'S new BULLETIN!



Send for your copy of the Ramco Bulletin. See how Ramco 2- and 3-dip degreasers can solve your metal parts cleaning problems, economically, efficiently, safely! Write today!

RAMCO EQUIPMENT CORP.
DIV. OF RANDALL MFG. CO., INC.
809 Edgewater Rd., New York 39, N.Y.

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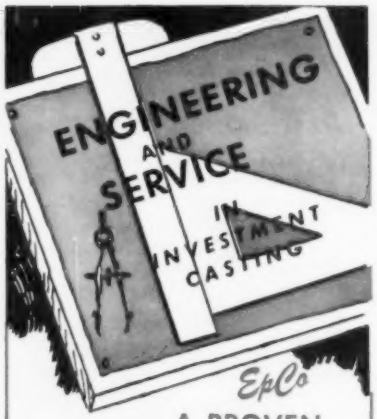
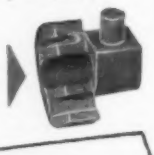


EpCo

A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING
Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.



ENGINEERED PRECISION CASTING CO.
MORGANVILLE, N. J.

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Metals and Applications
Design and Application
Processing and Fabrication
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The supplements make a worthy addition to your technical library and contain practical, authoritative information. Easy to use, these volumes put all metal facts at your finger tips.

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ASM Members—$4.00

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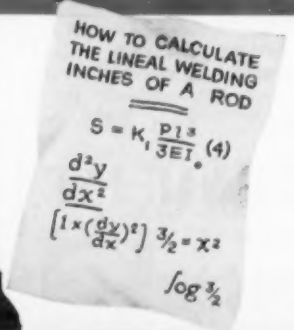
Order direct from ASM Headquarters in Cleveland. 7301 Euclid Avenue.

ASK WHITEY ABOUT WELDING STAINLESS


HOW TO CALCULATE THE LINEAL WELDING INCHES OF A ROD
$S = K_1 \frac{P l^3}{3EI}$ (4)
$\frac{d^2y}{dx^2}$
$\left[1 \times \left(\frac{dy}{dx}\right)^2\right]^{3/2} = x^2$
$\log 3/2$

Whitey says: "It takes a genius to count the cost beforehand—especially if he's only half familiar with his tools (but then he's no genius) . . . You can't guarantee a rod to weld any predetermined length of stainless without knowing the operator's technique, the type of joint, the fit—but, by knowing the make and quality of the rod you can be a bit psychic in your estimate."

Place a trusted guarantee back of your welding operations.

Stainless and Heat Resistant Arc Welding Electrodes of all analyses . . . coated, straightened . . . cut . . . coiled and spooled.

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Phone: MOntrose 2-6100

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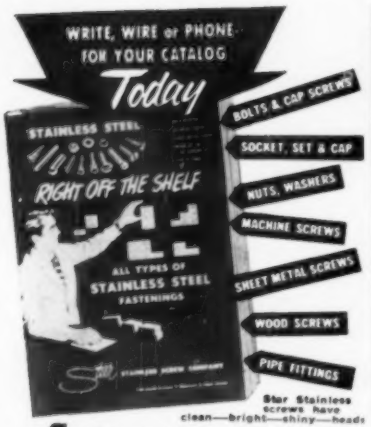

STAR STAINLESS SCREW CO.

CORROSION RESISTANT

647 Union Blvd., Paterson 2, N. J.
Telephone: CLifford 6-2300
Direct N.Y. 'phone Wisconsin 7-9041
Direct Phila. 'phone WAlnut 5-3660

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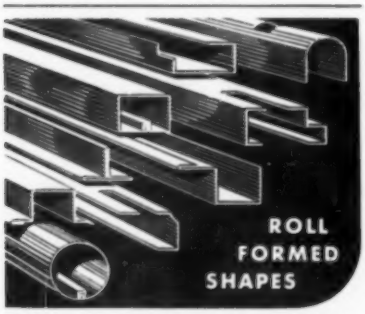

Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

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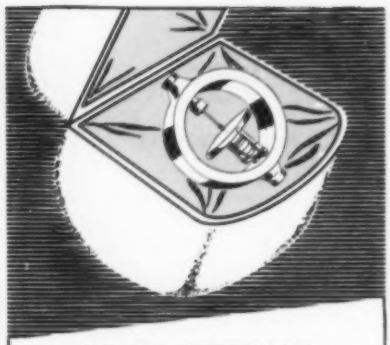

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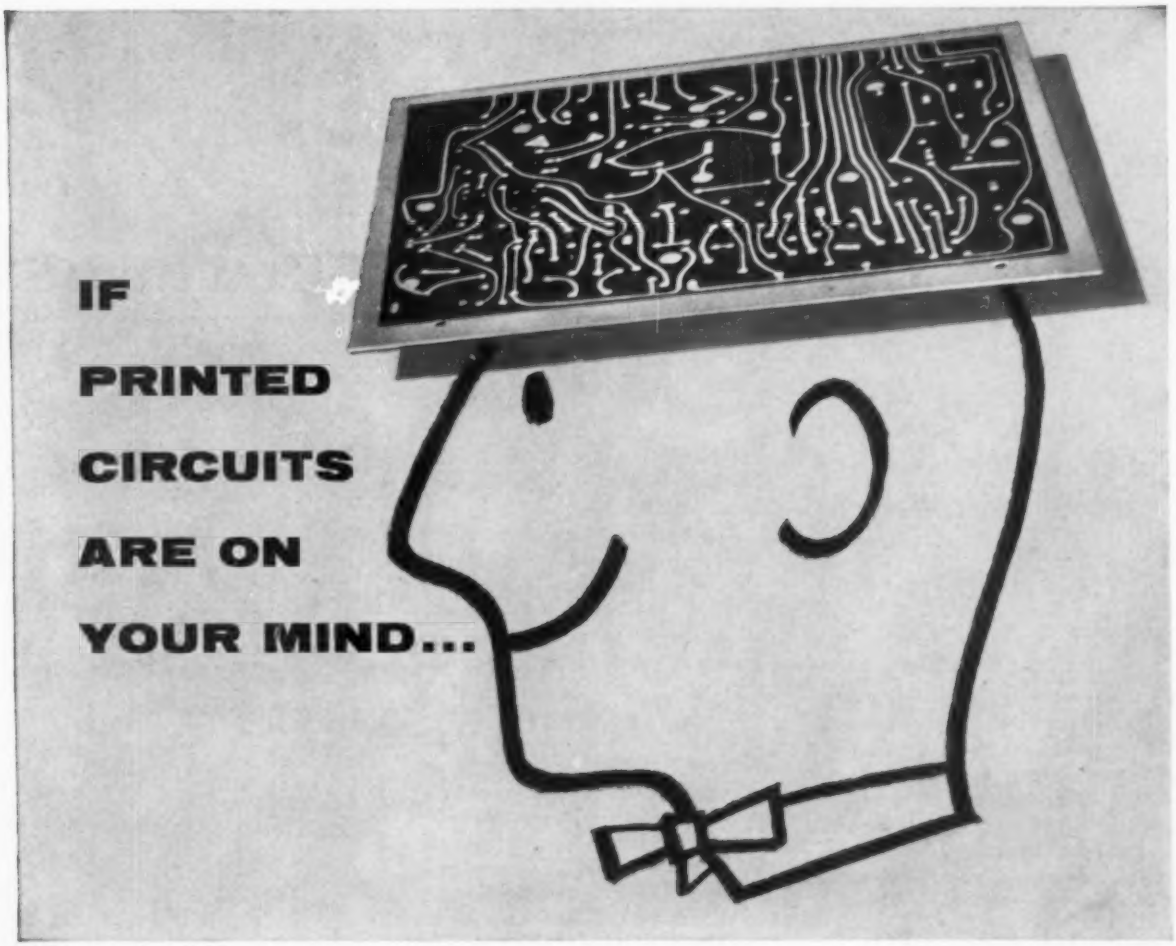

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Digests of ASM Convention Papers

Casting Aluminum Ingots Under Water

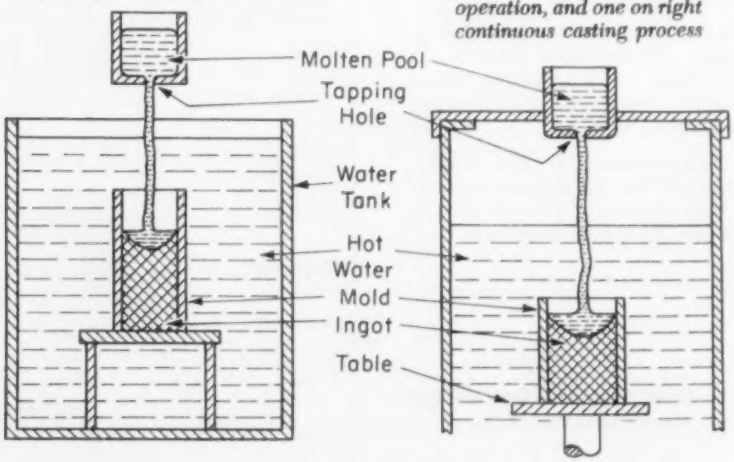
Digest of "Subaquatic Casting of Aluminum Ingots", by Ichiji Obinata and Hiroshi Tanaka, ASM Preprint, No. 67, 1958.

As THE TITLE indicates, this paper discusses the rather unusual technique of casting underwater. The process may be summarized as follows: Thin metal molds approximately $4 \times 4 \times 12$ in. high are placed in a large water tank and the molten aluminum poured through the water into the mold. The resulting ingots, which weigh approximately 19 lb., have a good surface finish and a completely equiaxed structure. The mechanical properties of these sound ingots compare favorably with the properties of normal chill cast ingots.

Experiments were also carried out on underwater continuous casting. The authors stress the fact that, by using proper casting conditions, a fine-grained equiaxed structure is produced in ingots 5 in. in diameter, 20 in. high, and weigh 44 lb.

The preliminary experiments and most of the chemical and mechanical tests were carried out on ingots cast into cylindrical molds 1.8 in. in diameter and 7.8 in. high. Tests were made for specific gravity, electrical resistance, hydrogen content, Al_2O_3) content, chemical uniformity and mechanical properties including tensile strength, percent elongation and hardness. The results given in table form show that no appreciable difference exists between conventional chill cast ingots and those produced by the new subaquatic casting (SAC) process. The exception to the above statement is that in the alloys used no inverse segregation was observed in the conventional chill castings. This is as expected, since the SAC castings were equiaxed in structure while the chill castings were columnar. No results are given for a casting with an equiaxed structure prepared by a conventional casting technique.

Fig. 1 – Subaquatic Casting Process. Left-hand drawing represents batch operation, and one on right continuous casting process



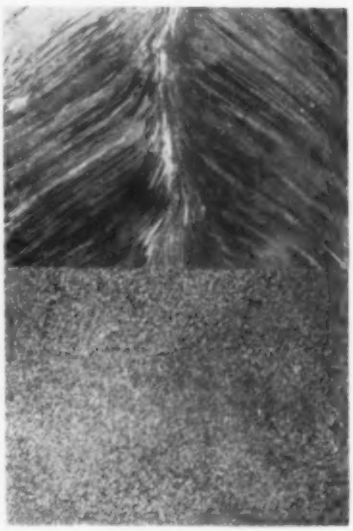
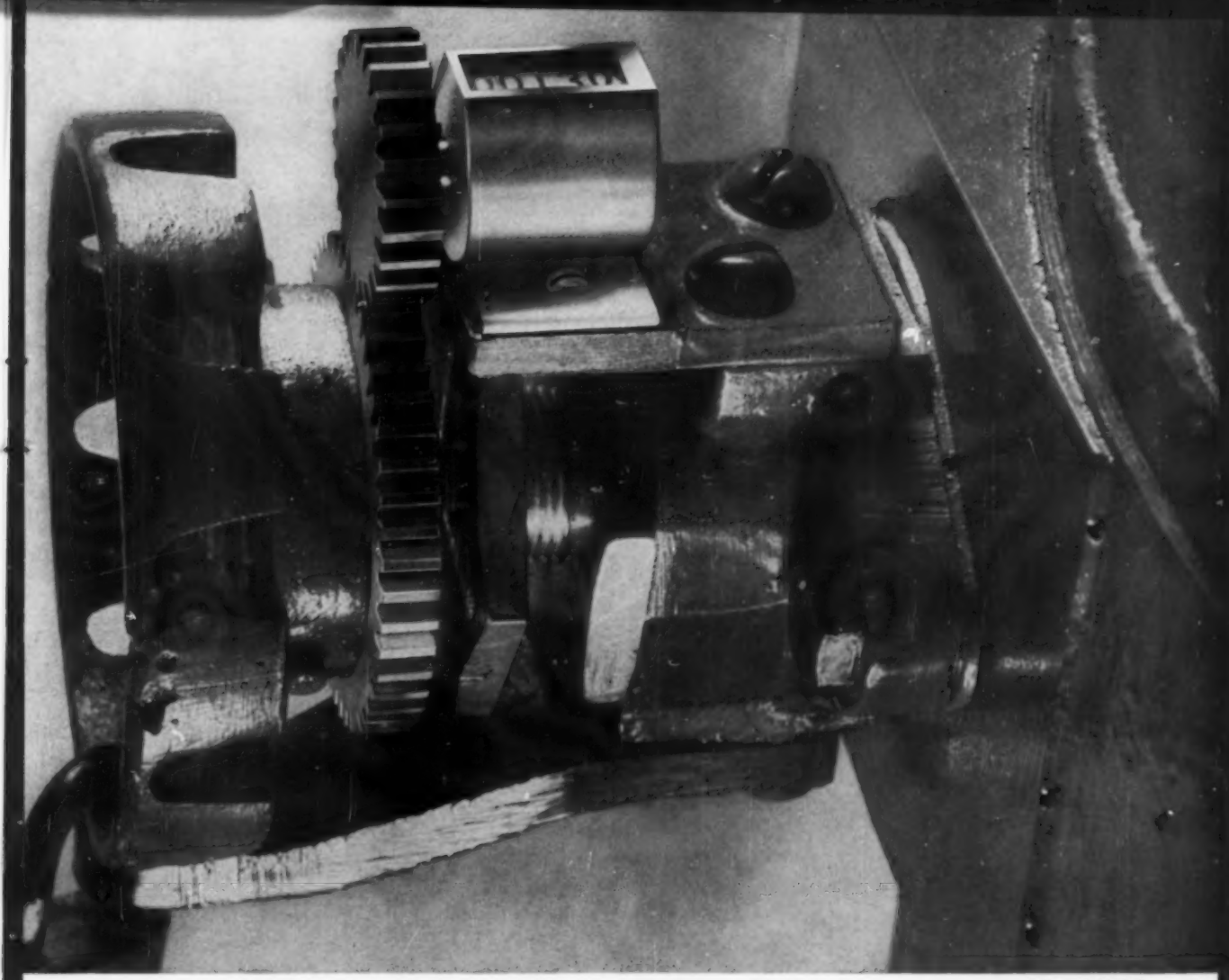


Fig. 2 – Macrostructures of the Longitudinal Section of 1100 Aluminum Ingots Cast by Batch Process (Above) and Cast Continuously (Below). Aqua Regia. × ½

Two possible cases of explosions when using the SAC process are given. The first of these is the sudden evaporation of water, and the second is the generation of hydrogen from the reaction $3H_2O + 2\,Al = Al_2O_3 + 3H_2\uparrow$. A water bath 300 times as large as the quantity of aluminum finally to be poured is recommended for safe practice as well as a large well-ventilated room.

In the authors' words, this process is "a method of making ingots by casting molted aluminum and its alloys in thin-walled metal molds set in hot water".

W. C. WINEGARD



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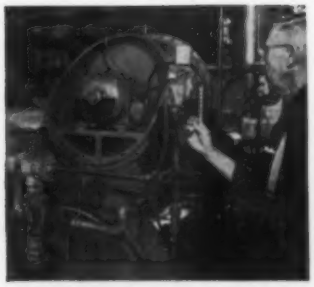

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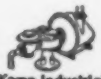

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Preparing Uranium Powder Metal Compacts

Digest of "Preparation of Uranium and Uranium Alloy Powder Metal Compacts", by Herbert S. Kalish, Preprint No. 63, 1958.

Powders suitable for compacting into high-density parts can be produced from calcium-reduced uranium as well as by decomposition of the hydride. The effect of processing conditions (for example, temperature and pressure of compacting) and subsequent treatment on the density and structure of the final product is examined. In order to achieve full density of cold pressed powder, very high-temperature sintering is required. Hot pressing in an inert atmosphere above 600° C. (1110° F.) will yield material of theoretical density.

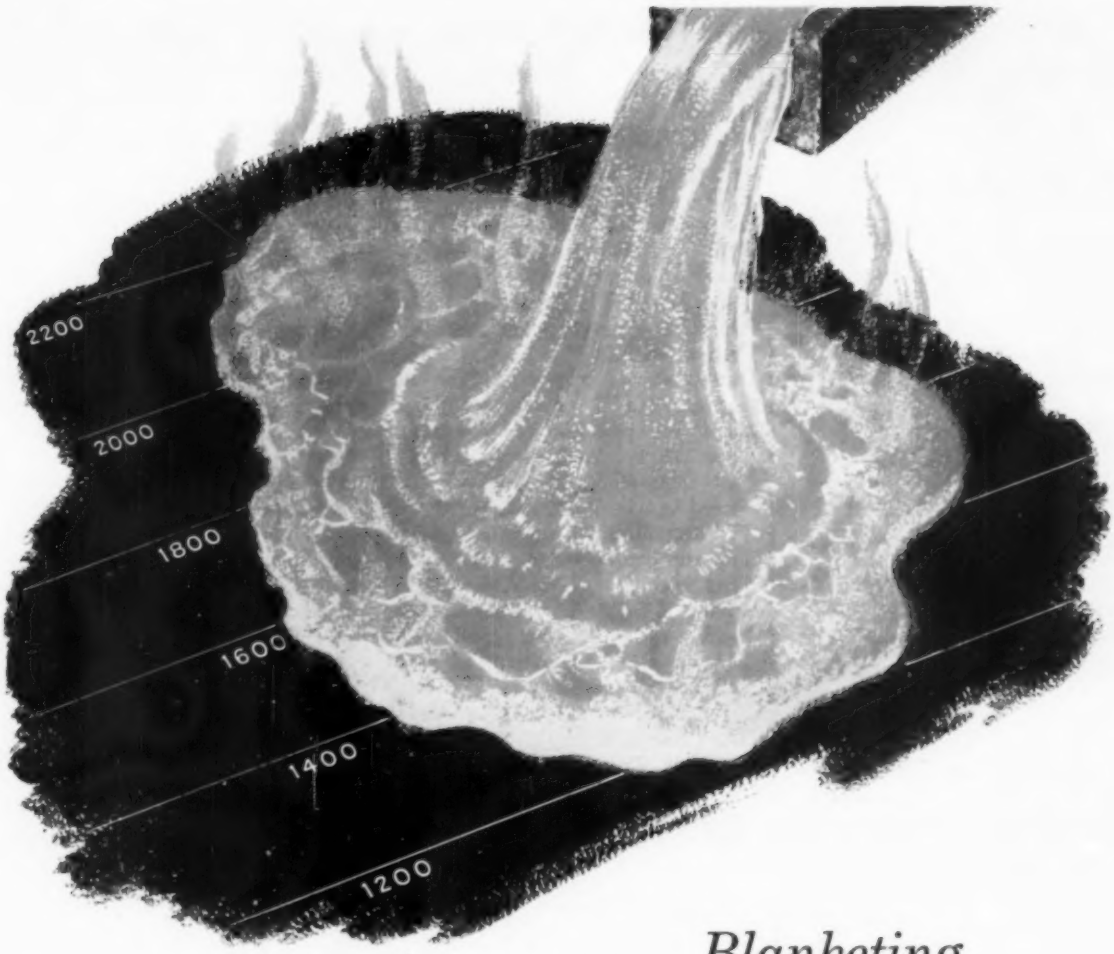
A number of lubricants were tried for cold pressing. Camphor, which is highly volatile, produces satisfactory lubrication with little effect on the properties of the sintered bar.

The product of hot pressing is fine grained and has little preferred orientation. The high-temperature sinter required on cold pressed powders produces a coarse-grained structure which cannot be refined even by cold work and recrystallization.

Alloys can be produced but they must be homogenized by annealing at 900° C. (1650° F.) or higher. Some alloying elements inhibit grain growth during the homogenization treatment and give a higher density product. Columbium and molybdenum are especially effective.

R. W. Guard

Fig. 1 — Operation of 200-Ton Press Inside an Argon Dry Box. Operator is loading powder into the die



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New developments in the production, marketing and uses of tin

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The increasingly important role of tin in this age of the jet and missile is again confirmed. A tin-zinc alloy is being used to plate jet aircraft hydraulic brake parts and thus prevent corrosion. The alloy is 75% tin and 25% zinc.

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Another new product is available in the popular aerosol cans. It is Freon, an odorless, colorless gas normally used as a refrigerating agent. The aerosol Freon bomb will double as your personal, portable tire pump and fire extinguisher. It can be used to inflate the average tire with 22 pounds of pressure in just 6 seconds. It kills fires by depriving the flames of oxygen and lowering the surrounding temperature.

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Fe-Cr-Ni-N System

Digest of "Phase Relationships in the Fe-Cr-Ni-N System", by G. F. Tisinai and C. H. Samans, ⊕ Preprint No. 71, 1958.

To ascertain the austenite-austenite plus ferrite boundaries of the iron-chromium-nickel-nitrogen system in the 21 to 33% Cr range with 0.20 to 1.1% N and with 1 to 20% Ni, a powder metallurgy technique was used for 59 of 82 alloy compositions studied. Chromium nitride (Cr_2N), chromium, nickel and iron powder were mixed for over 16 hr., compressed into pellets at greater than 80,000 psi., sintered in a vacuum at 2200° F. for 24 hr., and water quenched. After metallographic examination, the pellets were heated in a vacuum at 2000° F. for 20 hr., water quenched and re-examined metallographically. The remaining compositions were made in a high-frequency induction furnace, forged to greater than 90% reduction, and portions of the wrought alloys were held at 2300° F. for 2 hr., furnace cooled to 2200° F., held for 20 hr., water quenched and examined metallographically.

Phase relationships were studied at 2000° F. In pellets showing pronounced precipitation of nitrogen, the matrix tended to contain more ferrite than it did when quenched from 2200° F. When the nitride precipitation did not occur or was slight, the matrix tended to contain less ferrite than it did when quenched from 2200° F.

For each composition there is an optimum austentizing (solution annealing) temperature at which the maximum amount of austenite will be produced. Heat treating above this temperature tends to precipitate nitrides, deplete the matrix in nitrogen and increase ferrite content.

Considerable amounts of martensite or ferrite may form depending upon the original composition and degree of nitride precipitation. The matrixes of the alloys always retain some austenite even after extensive precipitation of nitrides (and carbides) since they do not becomes significantly depleted in nickel by the precipitation. This differs from similar alloys containing only carbon and nitrogen where the matrix decomposes completely to ferrite.

In alloys containing nominally 33 % Cr, sigma phase was found after nitride precipitation. Thus nitride (and carbide) precipitation in alloys containing less than 30% Cr reduced effective chromium content (in the matrix) so that sigma formation was slight if at all.

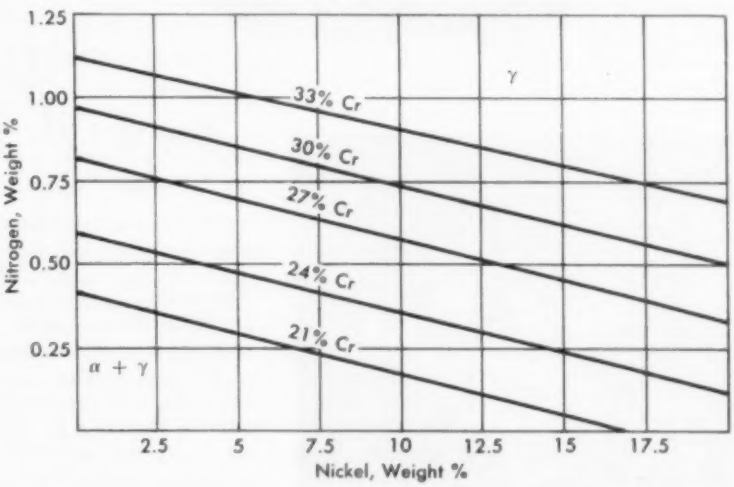

Fig. 1 — Austenite-Austenite Plus Ferrite Boundaries Within the Compositional Limits Studied

Figure 1 shows the austenite-austenite plus ferrite boundaries within the compositional limits studied. These boundaries are virtually straight lines at 2200° F. and parallel each other at various chromium levels. Thus, the nitrogen:nickel austenite substitution ratio is about 0.025:1 and is independent of the chromium in the range studied.

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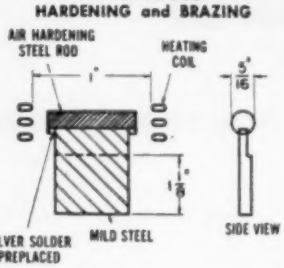

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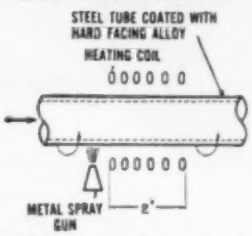
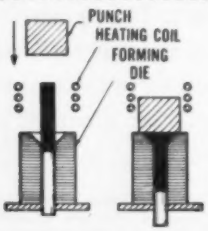


Corrosion or wear resistant metal coatings sprayed on metal surfaces can be improved by heating to achieve alloying by diffusion. The drawing shows a typical arrangement for processing steel tube sprayed with hard facing alloy. Long tubes may be progressively sprayed and heated.



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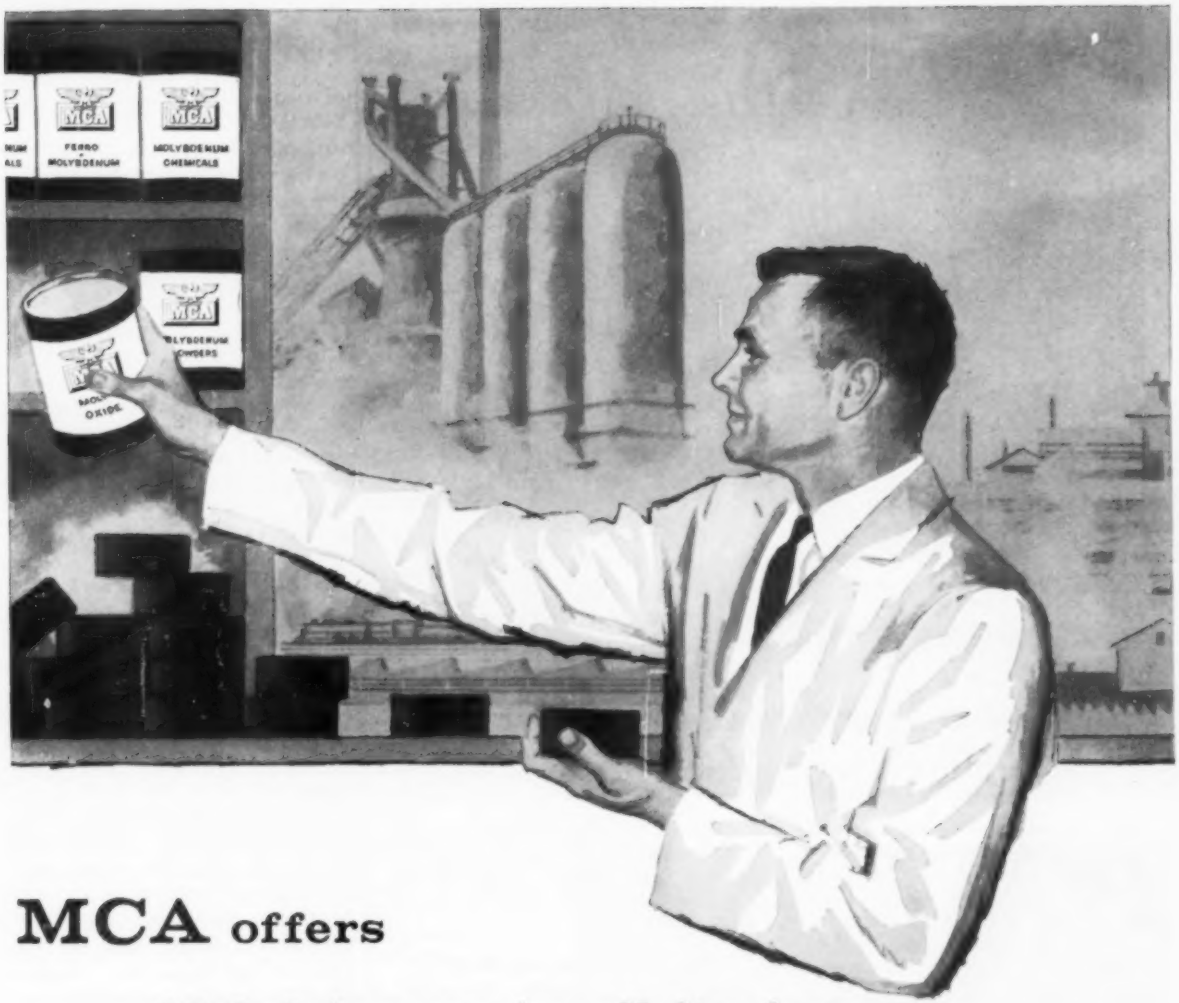
Recrystallization, Structure, Hardness of Copper-Bearing Steels

Digest of "Recrystallization, Structure, and Hardness of Low-Carbon Steels Containing up to 1% Copper", by R. L. Rickett and W. C. Leslie, Preprint No. 108, 1958.

THE PRESENT WORK shows that variations in the solid solubility of copper in low-carbon steels produces a copper-rich precipitate which markedly retards the rate of recrystallization on annealing after cold working and contributes, under favorable circumstances, to elongated grains which are desirable for deep drawing. Earlier work indicated that a precipitate of aluminum nitride produces similar effects in aluminum-killed low-carbon steels. Thus it appears that the control of recrystallization and grain structure of ferrite by precipitation of a second phase is a general phenomenon. Apparently it is necessary only to balance the rate of precipitation and the rate of recrystallization so that precipitation occurs simultaneously with, or slightly in advance of, recrystallization. Also, the precipitation should form preferentially in the boundaries of the prior cold worked grains.

The materials under study comprise laboratory induction-furnace and commercial openhearth steels, all rimmed, containing 0.03 to 0.08% C and 0.01, 0.27, 0.43, 0.61, 0.84 or 1.14% Cu.

To aid in interpretation of recrystallization data, information on solution and precipitation of copper in low-carbon steels was obtained by use of various tools including the electron microscope and X-ray diffraction. Because copper tends to segregate in austenite in the Ae_1 to Ae_3 temperature range, solution temperatures below (1300° F.) and above (1650° F.) this range were employed; if followed by air cooling, both give practically identical recrystallization behaviour after cold reduction. On air cooling from above the Ae_3 temperature (normalizing from 1650° F. in this work), some precipitation takes place in steels containing as little as 0.43% Cu. Additional precipitation



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Copper in Steel . . .

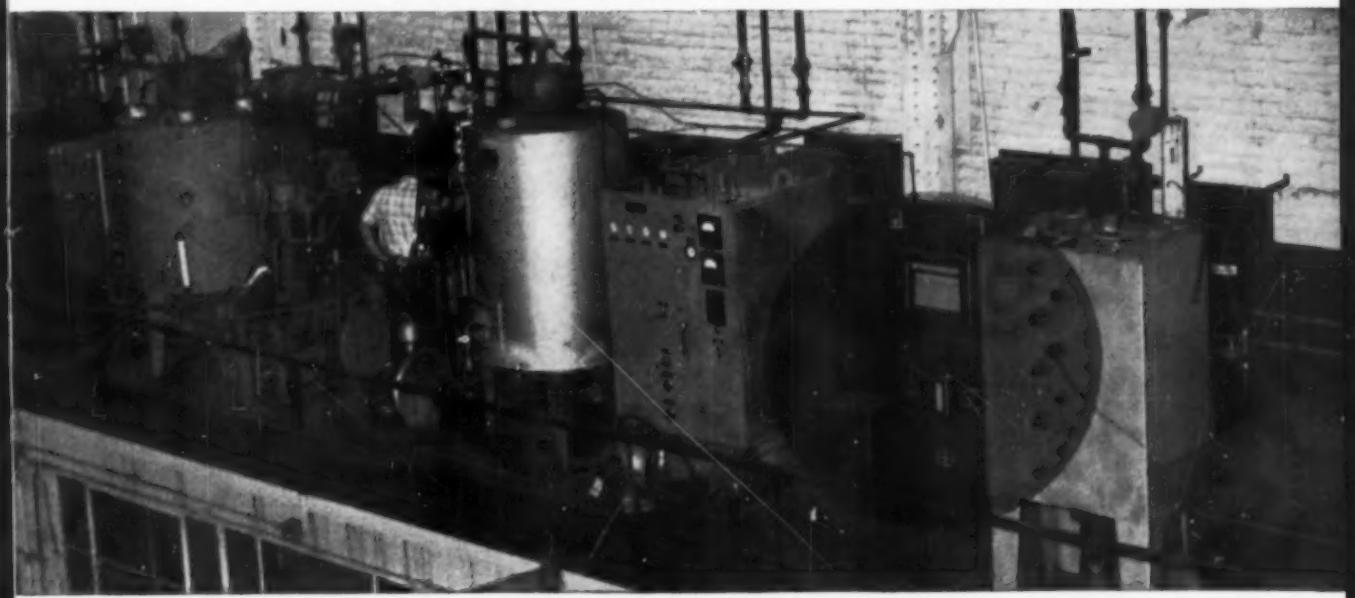
of copper occurs in these steels when held at 1100 to 1300° F.

Copper, in amounts from 0.27 to 0.84%, markedly increases the time required for recrystallization of cold reduced low-carbon steels at 1050, 1100 and 1200° F., if hot rolled material is solution treated for 30 min. at 1300° F. or normalized 1 hr. at 1650° F. prior to cold reduction. This effect is marked even if copper is partially precipitated by long holding at 1100° F. prior to cold reduction. (In this entire investigation, the amount of cold reduction is approximately 60% unless stated otherwise.) Holding at 1100° F. prior to cold reduction has no significant effect on recrystallization of 0.01 and 0.43% copper steels at 1100 or 1200° F., but it retarded significantly the 0.84% copper steel at 1300° F. Conversely, holding at 1300° F., to minimize the amount of copper in solid solution prior to cold reduction, accelerates recrystallization of the 0.61 and 0.84% copper steels at 1100° F.; however, it has no significant effect on the 0.43% copper steels. Despite this observation, after slow cooling from 1300° F. these steels are much more resistant to recrystallization than a steel without copper; therefore, it is apparent that copper has a marked effect in retarding recrystallization.

As indicated above, an elongated grain structure is usually desirable in these low-carbon steels. A simulated box anneal (slow heating and cooling) for 8 hr. at 1300° F. after cold reduction produced equiaxed grains in the 0.84% copper steel. Equiaxed grains were also produced in the 0.01 and 0.43% copper steels recrystallized isothermally at 1100° F. In the early stages of isothermal recrystallization at 1100° F., the 0.61 and 0.84% copper steels were largely elongated, but the elongated grains gave way to equiaxed grains as recrystallization progressed. This suggests that some process, possibly precipitation, taking place at 1100° F., during or prior to the early stages of recrystallization, favors production of elongated grains but that this effect is slowly dissipated on holding at 1100° F. After a number of unsuccessful attempts, it was learned that an elongated grain structure in cold reduced 0.4 to 0.9% copper

M-S-A® LIRA Analyzers help control dew point of furnace atmospheres

You can prevent damaging oxidation and change in carbon content of metal surfaces by measuring water vapor content with M-S-A infra-red analyzers



Typical installation shows M-S-A LIRA Analyzer calibrated for suitable dew point ranges to determine carbon potential of the furnace atmosphere.

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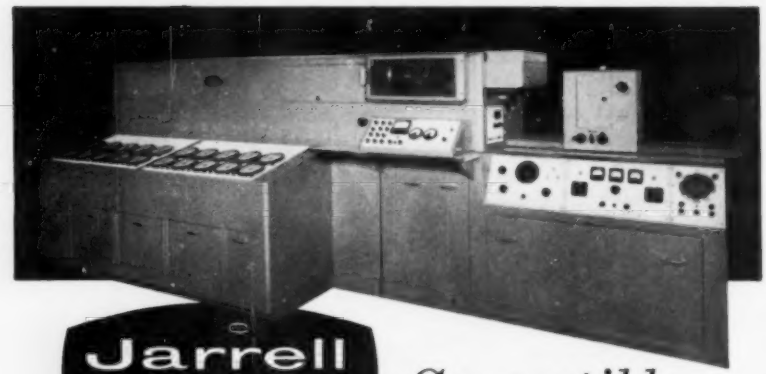

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Copper in Steel . . .

steels can be obtained by heating at approximately 200° F. per hr. to 1300° F. for recrystallization, or by pretreatment for 1 hr. or more approximately at 950° F. and then heating to a temperature just high enough to produce recrystallization within a few hours.

Increasing the amount of cold reduction in the range 20 to 80% increased the degree of grain elongation in copper steels treated to obtain an elongated grain structure. Effect of increased cold reduction is to increase hardness and decrease grain size after annealing.

When the annealed grain structure is equiaxed, hardness increases and grain size decreases slightly with increase in copper content. When the annealed grain structure is elongated, the effect of copper on hardness and grain size is counteracted by the tendency for the elongated grains to be larger and hence softer than the equiaxed grains.

In summary, copper greatly retards recrystallization of low-carbon steel and in general increases its hardness after annealing. Under proper conditions, comparatively coarse, elongated ferrite grains can be obtained in cold worked and annealed low-carbon steels containing 0.4% or more copper, in which case the hardening effect of copper is minimized. O. O. MILLER

Thermal and Load-Cycling Fatigue Tests

Digest of "Thermal and Mechanical Fatigue of Nickel and Titanium", by Harry Majors, Jr., ⊜ Preprint No. 105, 1958.

THERMAL and load-cycling fatigue tests were conducted on annealed, commercially pure nickel and titanium using machines of a design which had proven satisfactory in earlier investigations. Cycling was at the rate of 100 and 120 cycles per hr. during thermal fatigue testing of the titanium and nickel, respectively, and 60 cycles per hr. for all load fatigue tests. Temperatures were 525 and 575° F. for the nickel and titanium, respectively. These temperatures remained constant throughout the load-cycled tests and were maintained as the

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The thru-hardening steel—Timken TBS 600 steel—has a recovered hardness of 59 Rockwell C measured at room temperature after holding 500 hours at 600° F. Hot hardness at 600° F. is 56 Rockwell C which is extremely high for a low alloy steel.

The carburizing steel—Timken CBS 600 steel—exhibits a hot hardness of 56 Rockwell C and a recovered hardness of 61 after 500 hours at 600° F., at the 1% carbon level. Corresponding hardness for the core is 55 and 58 Rockwell C. Both steels contain less than 5% alloying elements.

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Fatigue Tests . . .

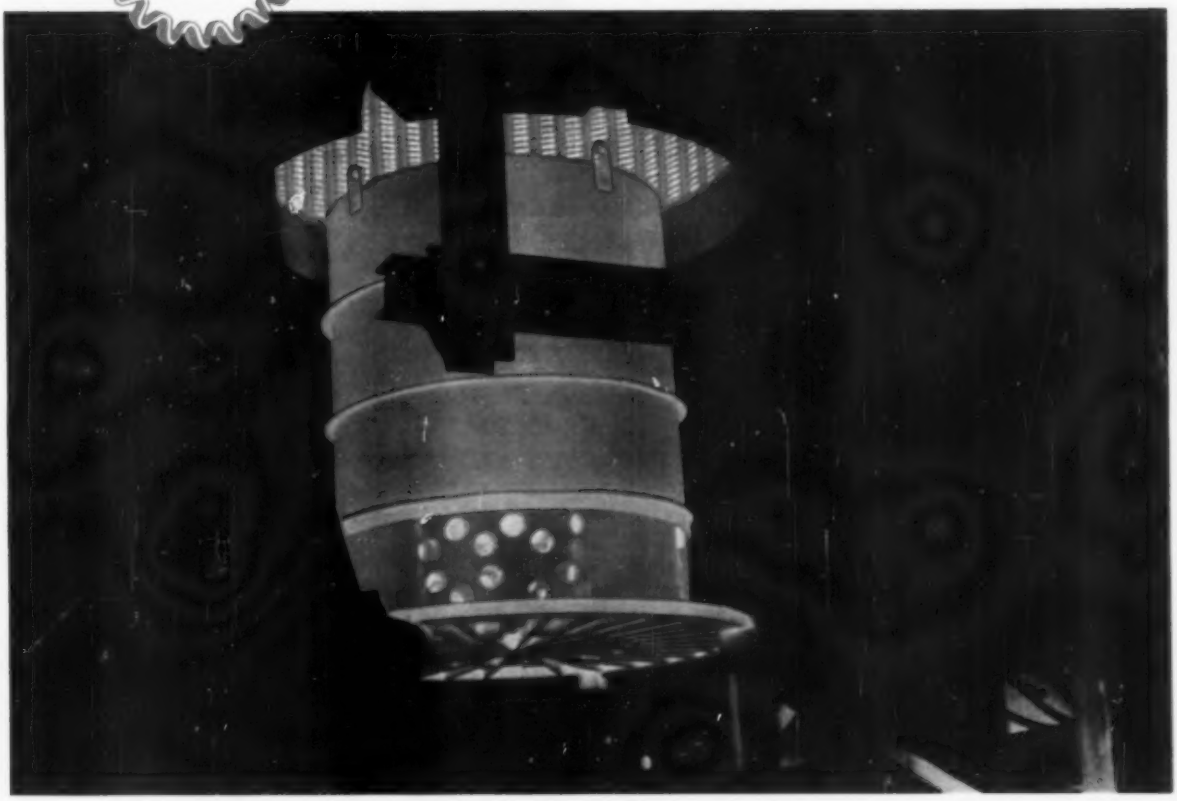
mean temperatures of the thermal-cycled tests. However, maximum, minimum and range of temperature varied from one thermal-cycled test to another as a result of maintaining a constant mean temperature. Temperature and hold times were adjusted to provide a nonvarying stress-strain hysteresis loop for all cycles (whether thermal or load-cycled) of a given stress range. Stresses and strains were determined and plotted against the log of the number of cycles to failure to provide fatigue curves which strongly resembled the asymptotic variety.

The test specimen, essentially, consisted of a thin-walled tube, 4 in. long, flared and strengthened at both ends for easy mounting and testing. The test section proper comprised a 2-in. straight tubular length, with $\frac{1}{2}$ in. ID and 0.020 in. wall thickness. Both inside and outside surfaces were fine finished longitudinally.

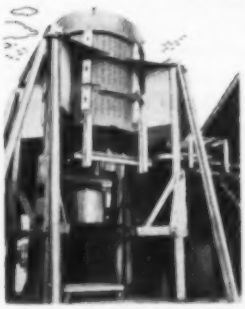
The fatigue tests were carried out in two machines of basically similar design. They consisted, primarily, of two horizontal plates, a base and head plate, separated by solid and hollow columns between them for the thermal and load-cycling machines, respectively. The test specimens were rigidly mounted longitudinally between the plates and subjected to alternate tensile and compressive stress. In the thermal-cycled tests, the specimen was alternately heated and cooled, and thereby stressed as a result of the restraining effect of the solid columns between the plates. The test stresses in the load-cycled tests were produced by alternate heating and cooling of the columns between the plates holding the test specimen. Suitably located dial gages, strain bridges and thermocouples provided the necessary information on strain and temperature conditions throughout the tests. Loading conditions were automatically maintained by electric timing circuits controlling the resistance heating and by forced air cooling of the hollow test samples and hollow columns.

The data relating the life values to the stress amplitude indicate that there is no appreciable difference in behavior between load-cycled and thermal-cycled titanium in the re-

KANTHAL heating elements



...again selected by PACIFIC SCIENTIFIC for gigantic SOLAR honeycomb brazing furnace



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MEDIUM CARBON (Grade B Medium)	70,000 (Min.)	38,000 (Min.)	24% (Min.)	36%	140-170	Comparable to SAE 1025. Good machinability. Above average physical properties. Weldability excellent. Good ductility.
MEDIUM HIGH CARBON (Grade B Medium High)	80,000	43,000	18%	30%	170-190	Comparable to ASTM-A-148-46T 80—40. Slightly higher carbon than "Medium" grade with higher tensile properties. Decreased ductility. Water quench will increase hardness. Pre-heating and post-heating recommended for welding.
HIGH CARBON (Grade B High)	85,000	52,000	17%	25%	179-217	Comparable to SAE 1045. Attained higher tensile properties result in slightly less ductility. Suitable for high surface hardness. Welding difficult unless pre-heated and post-heated.

ALLOY STEEL CASTINGS

PHYSICAL PROPERTIES* T-LOY 34	HEAT TREATMENT: Normalized & Drawn	Oil Quenched & Drawn 1200° F	Oil Quenched & Drawn 900° F	GENERAL CHARACTERISTICS
Tensile Strength p.s.i.	90,000	105,000	150,000	Comparable to SAE or AISI 8632. Oil quench produces excellent tensile strength properties ranging to 150,000 p.s.i., coupled with high ductility, wear resistance and immunity to temperature changes. Specific areas may be flame or induction hardened.
Yield Point p.s.i.	60,000	85,000	125,000	
Elongation in 2"	20%	17.0%	10.0%	
Reduction of Area	40%	35.0%	25.0%	
Brinnell Hardness	187-217	217-246	305-342	
T-LOY 42				
Tensile Strength p.s.i.	100,000	120,000	175,000	Superior to SAE or AISI 8640. Recommended when high strength and hardness are desired in the normalized and drawn condition. Deeper hardening obtained by oil quench and draw with tensile up to 175,000 p.s.i. High degree of hardness will be attained with spot or flame and air cooling. Water quench not recommended.
Yield Point p.s.i.	75,000	100,000	145,000	
Elongation in 2"	12%	12%	10%	
Reduction of Area	25%	28%	25%	
Brinell Hardness	217-246	250-280	350-380	

* Physical properties based on a .505" test bar turned from a standard 1¼" cast test coupon.

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Fatigue Tests . . .

gion of 3,000 to 10,000-cycles life; but beyond 12,000 cycles, stresses in thermal fatigue are lower than in mechanical fatigue for equal life. For nickel, the thermal stresses are consistently less than the load stresses for equal life and at 100,000-cycles life the difference is 20%.

In plotting life values against strain, only the plastic strain values were used. These were calculated from observed values of total strain, stress range and the average modulus of elasticity over the temperature ranges used in the tests. When interpreted in relation to plastic strain range, the test results indicate that the amount of plastic strain which can be sustained under thermal fatigue loading is only a fraction of that which can be sustained under mechanical fatigue loading.

For the same mean temperature and life to rupture, nickel can absorb twice the plastic strain under load cycling as it can absorb under thermal cycling. Similarly, titanium under load cycling can absorb 5½ times the plastic strain that it can absorb under thermal cycling. It is not known what the effect is of variation in maximum, minimum and range of temperature inherent in the thermal fatigue cycling tests, but it may be appreciable.

Metallographic examination of ruptured fatigue specimens disclosed that some variation in grain size of the nickel occurred and that some coarse twinning took place in some areas in the titanium, but it was felt that neither had more effect on the results of this study than is inherent in the experimental errors.

A. J. MILLER

Forging Titanium Alloys

Digest of "The Influence of Forging Temperature on Mechanical Properties of Al-V Titanium Alloys", by L. S. Croan and F. J. Rizzitano, Preprint No. 75, 1958.

ALTHOUGH the aluminum-vanadium titanium alloys are considered among the most satisfactory of presently available alloys, they are difficult to forge, particularly in the 1650 to 1750° F. range commonly used in the titanium industry. This

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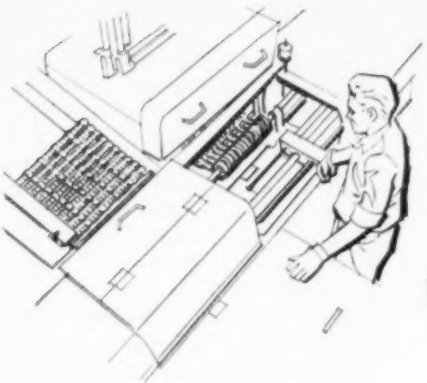

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Forging Titanium . . .

paper describes an investigation of the effects of forging temperature, reduction ratio, cooling rates after hot work, and various heat treatments on the properties of two 6 Al, 4 V alloys and one 7 Al, 4 V alloy.

In experiments with the 6 Al, 4 V alloy, the 8¼-in. diameter bar was drop forged at 1800° F. to 2¼ in. diameter, machined to 2 in. diameter and cut to suitable lengths. Two billets 4½ in. long were upset press forged (die temperature 450° F.) at each of the following temperatures, 1700, 1900 and 2200° F., and water quenched after forging. Final thickness of all billets was 1½ in. and approximately 3⅛ in. in diameter. All billets were heat treated at 1725° F. for 1½ hr. and water quenched, followed by heating to 1100° F. for 2 hr., and air cooled. Two standard transverse V-notch Charpy specimens and two 0.252-in. diameter transverse tensile specimens were cut from each forging. Impact properties at −40° F. and tensile properties at room temperatures were obtained.

In another series of tests, 2-in. diameter machined bars, 3 in. long, from the above heat were upset forged to ⅝-in. thick plate at temperatures of 1650, 1750, 1850, 1950 and 2200° F. with water quench after forging. These disks were quartered and subjected to the following treatments:

1. Heated to 1725° F. for 1 hr., water quenched; heated to 1050° F. for 1½ hr., air cooled.
2. Heated to 1550° F. for 1 hr., water quenched; heated to 900° F. for 24 hr., air cooled.
3. Heated to 1725° F. for 1 hr., water quenched; heated to 1050° F. for 1½ hr., water cooled.
4. Heated to 1600° F. for 1 hr., water quenched; heated to 900° F. for 24 hr., water cooled.

Standard V-notch Charpy values at −40° F. microstructures and standard tensile properties were obtained on all specimens.

Billets 4 in. long and 2 in. in diameter from a second 6 Al, 4 V alloy heat were also upset press forged in open dies to ⅝-in. thick plates and water quenched at the press. Forging temperatures were the same as the above series. Heat treatment was 1725° F. followed by a water

quench; then heated to 1050° F. for 1½ hr. and air cooled. Charpy impact values and mechanical properties were similarly determined on this series which supplied additional information on commercial material.

In the final series, the 7 Al, 4 V alloy was press forged at 1750 and 1950° F. from billets 4½ in. in diameter and 4 in. long to make 1½-in. thick plate. Transverse Charpy impact values at −40° F. and tensile properties were obtained on these specimens water quenched from 1750° F. and aged for 1½ hr. at 1050, 1100 and 1200° F.

Results are as follows:

1. Microstructures of plates forged below the beta transus (1650 and 1750° F.) consist of primary alpha globules in a matrix of transformed beta. Forging at temperatures above the beta transus results in an acicular structure with a banded appearance; primary alpha globules are absent.

2. Tensile elongation decreases with increasing forging temperature. This decrease is a gradual one with increasing forging temperature.

3. Impact values increase with increasing forging temperature. This, however, is not a gradual increase but markedly improves above the beta transus.

4. The best combination of V-notch Charpy values is obtained by forging just above the beta transus and water quenching.

5. Process losses are reduced by forging at higher temperatures (above the beta transus) and water quenching at the press.

PAUL G. NELSON

Abrasive Tumbling

Digest of "Stress Effects of Abrasive Tumbling", by H. R. Letner, SAE Preprint No. 104, 1958.

THE BENEFICIAL EFFECT of surface working on fatigue life of highly stressed machine and engine parts is a well established fact. Commercial methods for inducing the favorable surface compressive stresses responsible for the fatigue improvement include shot-peening, tumbling, burnishing and surface rolling. To achieve good control over such operations, it is important to have information relating to the influence of variations in processing technique

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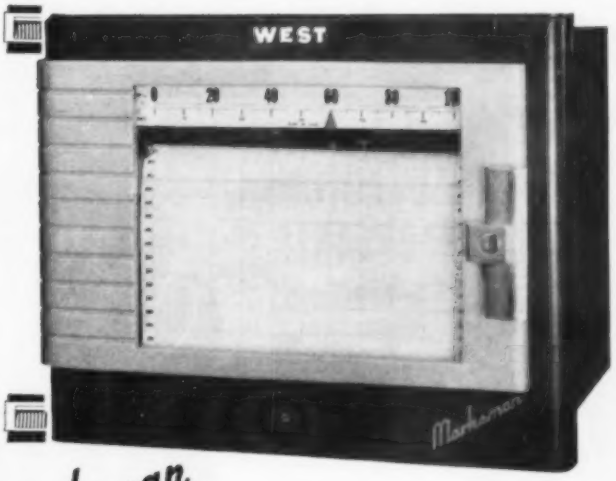

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Abrasive Tumbling . . .

on the magnitude of the stress in the surface and immediate subsurface layers. Improved methods for determining stresses, developed in the last few years, are being used in intensive investigation of the distribution of stresses as a function of depth in surface worked products.

In this investigation, stresses were determined in a number of tumbled test specimens of manganese oil hardening toolsteel employing a technique of controlled progressive etching of the cold worked surface in stages alternating with deflection measurements of the opposite protected surface made with a comparator. Experimental design embraced all material and process variables including:

1. Steel hardness – Rockwell C-64, 53, 32 and 10.
2. Initial stress state – one group with quenching stresses, one with grinding stresses and one stress-relieved by etching.
3. Tumbling medium – various sizes and shapes of abrasive pellets of emery and fused alumina and steel burnishing balls.

The residual surface stresses induced in the stress-free steel specimens by tumbling were compressive in all directions parallel to the surface with the maximums varying from 80,000 to 400,000 psi. depending upon steel hardness and intensity of working. The stress distribution in steel at hardness levels of Rockwell C-64 and 53 typically disclosed a sharp decline with distance from the surface, the compressive stress generally diminishing to zero at a depth of about 0.002 in.

The penetration increased as the steel hardness declined so that at Rockwell C-10 compression prevailed to a depth of 0.012 in. The maximum stress at the surface was also significantly affected by hardness ranging from 400,000 psi. in the most severely worked as-quenched samples to about 80,000 psi. in annealed pieces.

Both the magnitude of surface stress and the thickness of the stressed layer increased with the particle size of the tumbling medium, while the type of abrasive and shape of the particles had little influence. Tumbling with steel balls appeared to be somewhat less effective than

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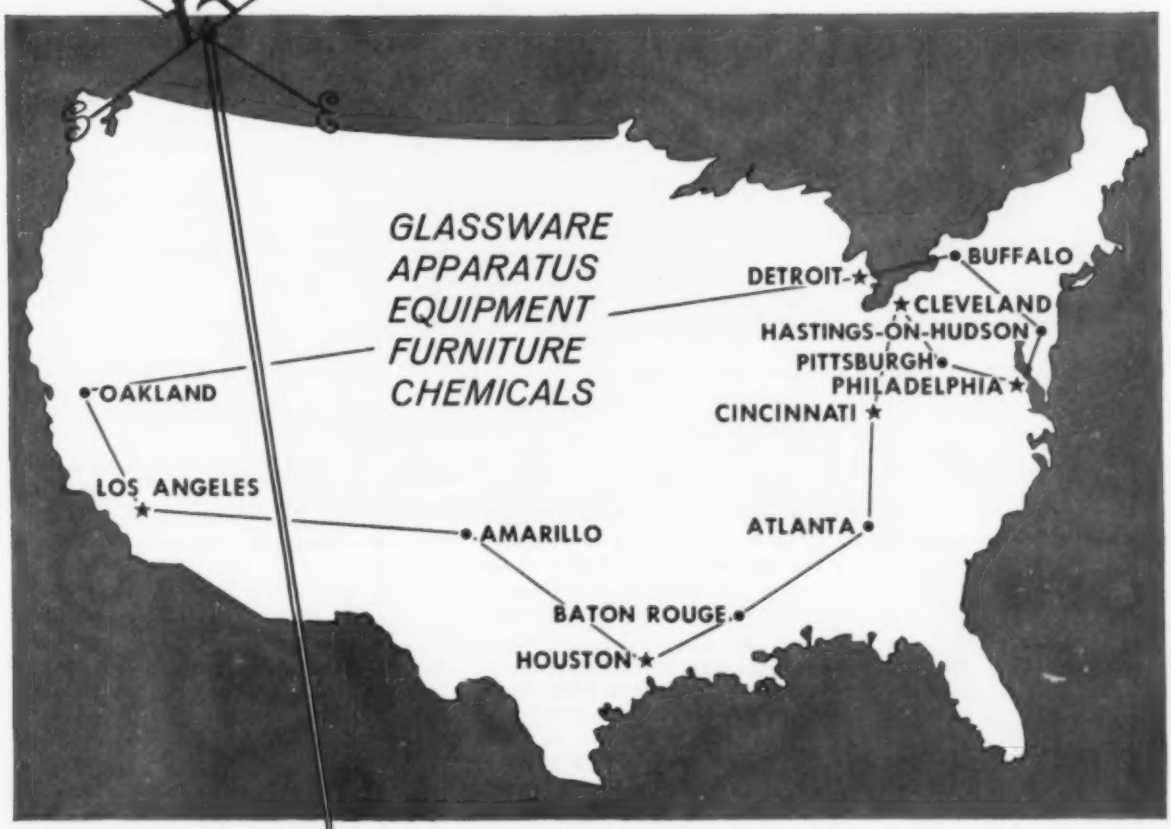

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Abrasive Tumbling . . .

with abrasive pellets of comparable size. The initial stress state had little influence on final stress pattern when the intensity of surface working was sufficient to produce a favorable degree of surface compression.

Abrasive tumbling is generally used with the objective of removing scale or rust, cleaning, deburring and breaking edges or altering the finish of parts, but the author points out that in some cases unsuspected dividends are being derived from these operations because of the stress patterns produced and the resulting improved resistance to fatigue. More extensive and intelligent use of such practices should be possible based on the information presented in this paper.

H. Y. Hunsicker

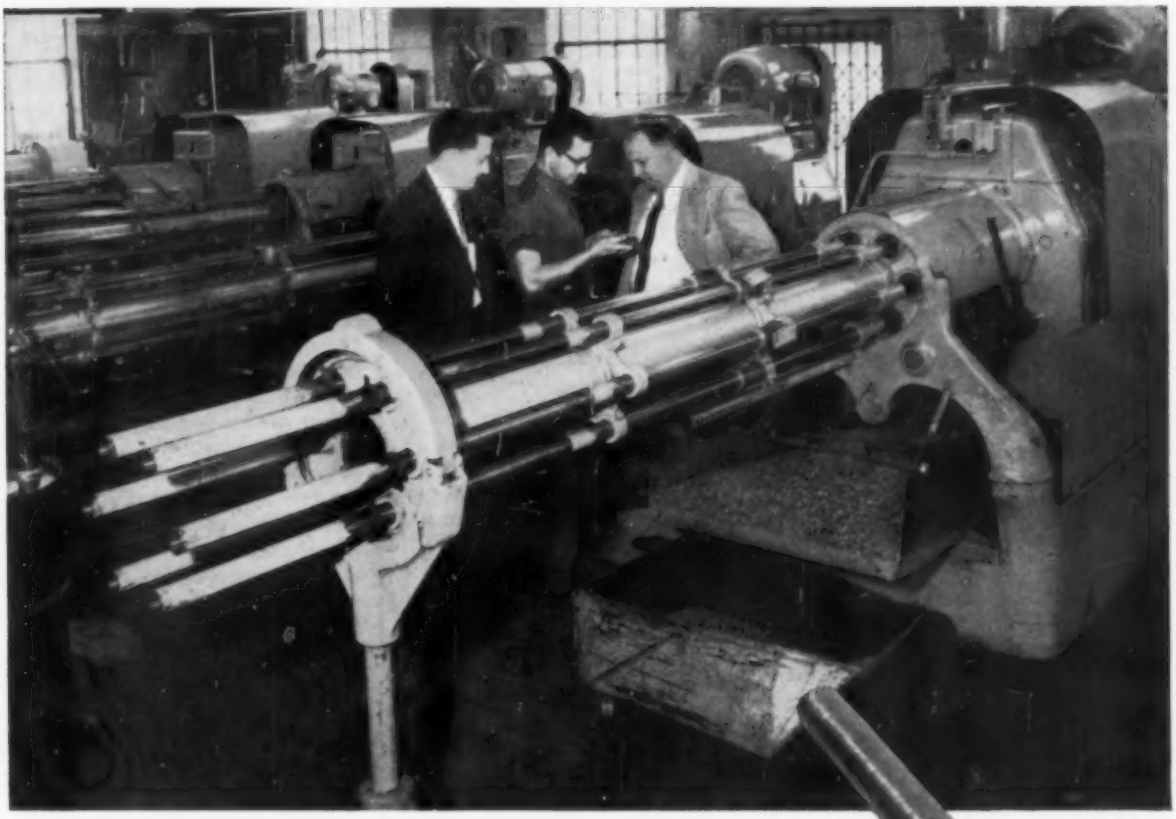
Heat Treatment of Zirconium-Uranium Alloys

Digest of "The Mechanical Properties and Heat Treatment Response of Zirconium-Uranium Alloys", by W. Chubb and F. A. Rough, ⊜ Preprint No. 84, 1958.

Zirconium has such favorable nuclear, mechanical and corrosion properties that it is used in nuclear reactor fuel elements. It is used in the metallic form as a corrosion resistant cladding, or alloyed with uranium as a fuel alloy core. Such applications require knowledge of the mechanical properties and heat treatment response of zirconium-uranium alloys in order to establish practical fabrication and heat treatment schedules.

The alloys were prepared using high-purity uranium and three grades of zirconium representative of different production processes. A series of alloys, ranging from 7 to 70 wt.% U, was subjected to end quench tests from 900° C. (1650° F.) and examined using hardness surveys, supplemented by metallographic and X-ray diffraction methods to identify phases. Quenched alloys were also given annealing tests to determine the practicability of relieving the extreme hardness and brittleness developed in quenching some of these alloys, and to establish appropriate annealing cycles.

The entire range of alloys made



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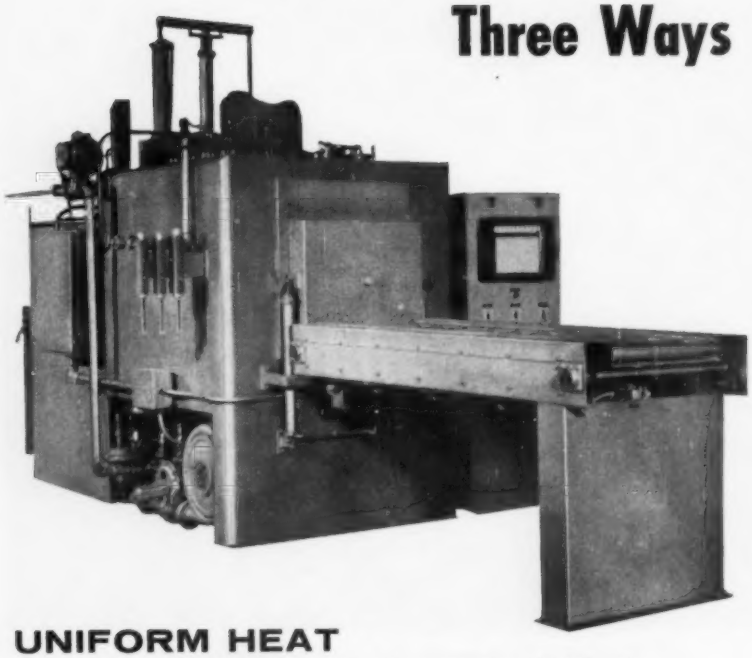

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Heat Treatment . . .

from iodide zirconium was tensile tested in one condition of heat treatment, that is, hot rolled to $\frac{1}{16}$-in. sheet and annealed at 575° C. (1065° F.) for 24 hr. Selected alloys were tested in different conditions of heat treatment. Room-temperature tests were run in air, high-temperature tests in helium – all at a strain rate of about 0.007 in. per in. per min. Dynamic moduli were determined by measuring the resonant frequency of a loosely supported beam. This test shows exceptional promise as a research tool.

Examination of the constitution diagram of the zirconium-uranium system shows an intermetallic, Zr_2U. Above about 600° C. (1110° F.), Zr_2U decomposes into a soft beta zirconium-gamma uranium solid solution, so that all zirconium-uranium alloys can be fabricated hot. The data from this investigation show that this soft beta can be retained at high quenching rates in alloys of from 40 to 70% U, but that hardening in the beta phase takes place at somewhat slower quenching rates or lower alloy contents, down to about 10% U. Metallographically, the quenched alloy appears to be retained beta zirconium, and the brittleness and high hardness appear to be due to changes of a coherent nature resulting from lattice distortion or an increase in bond strength.

In the continuous cooling of the alloys during end quenching, a relatively soft martensite can be produced in alloys containing 10 to 20% U. Slower cooling rates produce acicular alpha zirconium and Zr_2U. The hardening which occurs in these treatments appears to be associated largely with the coherent changes within the beta phase. In alloys containing 60% U, alpha uranium precipitates from the Zr_2U phase at low cooling rates.

The investigation established that minimum hardness and maximum ductility can be achieved in the different quenched alloys by annealing just below the alpha-plus-beta-to-beta transus temperature for a short time, followed by an appropriate furnace cooling schedule. It also established that zirconium-uranium alloys retain useful long-time strength to about 500° C. (930° F.).

E. C. MILLER

Weld Cracking in Magnesium Alloys

Digest of "The Relationship Between Weld Cracking and Alloy Constitution in Some Binary and Ternary Magnesium Alloys", by C. L. Kobrin and R. A. Dodd, Preprint No. 101, 1958.

MAGNESIUM ALLOYS are readily joined by gas welding and inert-gas-shielded arc welding methods. A problem which is common to many other metals joined by fusion welding and gives occasional trouble with certain magnesium alloys is that of weld cracking. Since no solid-state transformations are involved, weld cracking of magnesium alloys would be expected to be of the type which occurs during solidification rather than below the solidus temperature. A considerable background of investigations of aluminum alloys, particularly those of British workers, have shown that under these conditions the tendency for cracking increases in proportion to the solidification temperature range of the alloy and is dependent upon constitutional relationships existing under the conditions of solidification of the weld deposit.

A modified circular "patch" test was used to evaluate weld cracking tendencies of binary alloys in the systems Mg-Zn, Mg-Al, Mg-Sn, Mg-Pb and Mg-rare earths as well as ternary alloys of Mg-Al-Zn and Mg-Zn-rare earths. Tests involved deposition of weld metal in circular grooves ⅛ in. deep, ⅛ in. wide and 3 in. in diameter cut into sand cast ¼-in. thick plates. The weld was produced by the helium-shielded arc method using filler metal of the same composition as the parent plate. Weld cracking susceptibility ratings were based on average total length of surface cracks observed in several tests of each composition.

Of the binary alloys tested, only those of the Mg-Zn system cracked. The extent of cracking varied with increasing zinc content in accordance with the change in nonequilibrium solidification temperature range and eutectic content of the alloys. The lack of cracking in alloys of the other binary systems was attributed to their smaller, more favorable solidification temperature ranges. The restrained weld test

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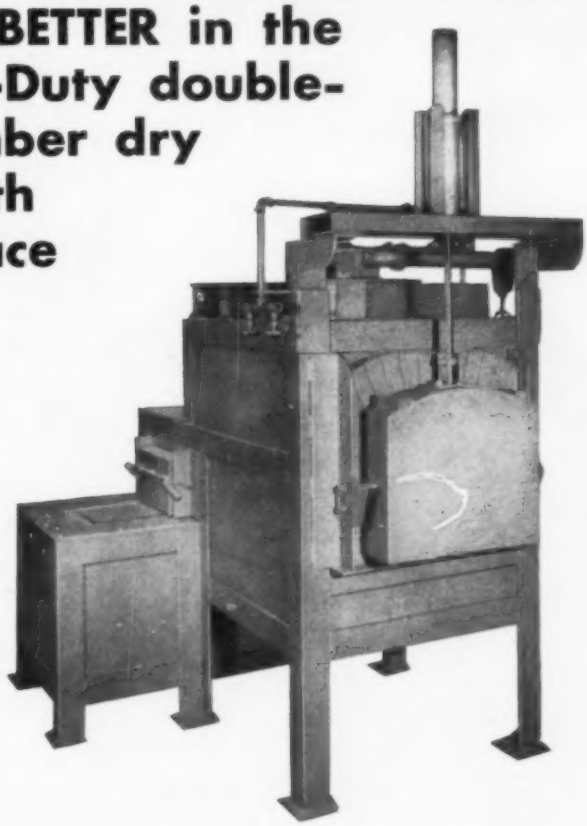

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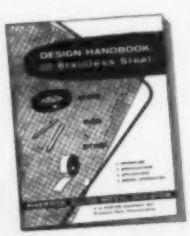

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Weld Cracking . . .

was apparently insufficiently severe to reveal any hot short tendency in the Mg-Al alloys.

Results obtained for the ternary systems, Mg-Al-Zn and Mg-Zn-rare earths, which are the basis for important industrial alloys, were summarized in contour charts and indicated that only the alloys relatively rich in zinc would be expected to afford substantial difficulty with weld cracking.

The weld cracking characteristics of the magnesium alloys were related to the solidification temperature range and eutectic content, as determined by alloy constitution under the nonequilibrium conditions of welding, and the tendency for cracking was consistent with theories based on observations of the relative susceptibilities to weld cracking and hot tearing of aluminum alloys.

H. Y. HUNSICKER

Measuring Austenite Transformation

Digest of "Austenite Transformation and Incubation in an Alloy Steel of Eutectoid Carbon Content", by R. A. Grange, P. T. Kilhefner, Jr., and T. P. Bittner, ⊕ Preprint No. 93, 1958.

THERE IS A NEED for continuous cooling diagrams to accurately predict the transformation products of austenite. The experimental difficulties in determining such diagrams, however, has led to efforts to predict them from existing isothermal transformation diagrams.

This paper presents continuous cooling (C-T) and isothermal (I-T) transformation diagrams for a Ni-Cr-Mo eutectoid steel (0.57 C, 1.16 Ni, 1.07 Cr, 0.26 Mo), compares the measured C-T diagram with one derived by various methods from the isothermal transformation diagram, and presents data on the influence of incubation to explain the discrepancy between measured and derived diagrams in the bainite region.

The C-T diagram was determined by austenitizing specimens at 1700° F., cooling at substantially constant rate to subcritical temperatures, microscopically measuring the percentage of austenite transformed and

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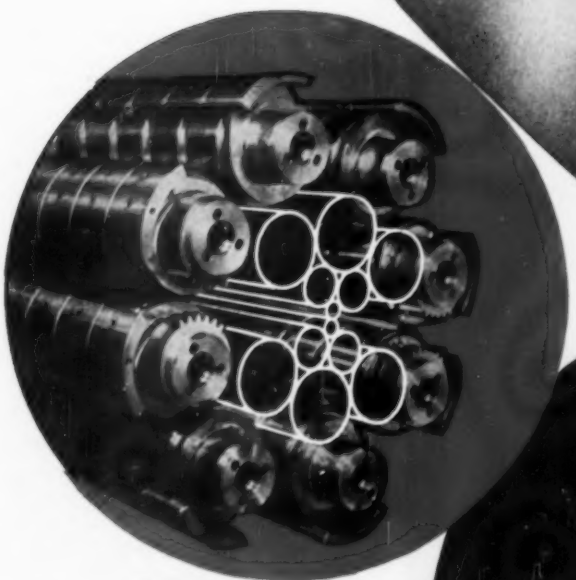
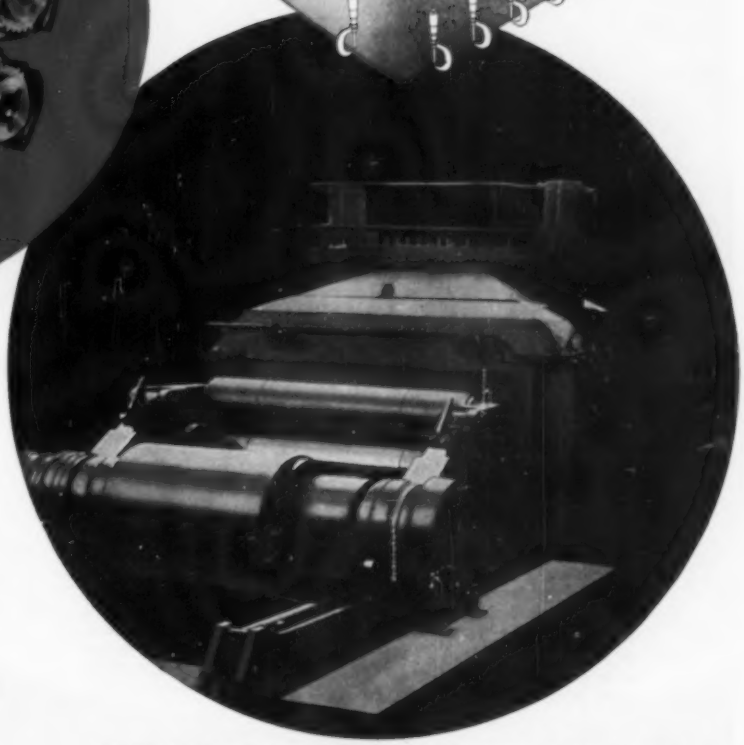


Phantom view of roll arrangement



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Even the critical countdown can't pre-test every vital factor before launching an earth satellite. Weld metal performance at diverse temperatures, various pressures and speeds can be known only through operation. Explorer I—America's first earth satellite—and Explorer III—designed and built at California Institute of Technology's Jet Propulsion Laboratory—both carry welds made with Arcos materials. Arcos CHROMENAR 12 (Type 410 stainless bare wire) was selected for welding certain components. Here's proof again why Arcos Welding Rods and Bare Electrodes are used so widely when results and performance must be predetermined as accurately as possible. ARCOS CORPORATION, 1500 South 50th Street, Philadelphia 43, Pa.

Austenite . . .

plotting the subcritical temperature versus cooling time below 1450° F. This method of plotting is experimentally justified. The I-T diagram was determined by conventional techniques.

The C-T and I-T diagrams vary significantly as expected. However, the difference is due to variation in the rate of transformation rather than to any fundamental difference in the nature of the transformation products.

Comparison of the measured C-T diagram and that derived from the isothermal diagram, by the method of Grange and Kiefer, shows a wide discrepancy particularly in the bainite region, much too low hardenability being predicted by the derivation. Other methods of predicting continuous cooling transformation are also unsatisfactory for the steel.

When austenite is cooled below the equilibrium transformation temperature, there is a time lag in the onset of detectible transformation which may be called an incubation period. Methods for deriving C-T diagrams from isothermal transformation data assume the incubation effects to be simply additive. However, experiments conducted by the authors, to determine the effect of incubation at different subcritical temperatures upon subsequent austenite transformation at 800° F., show that the effects of incubation depend significantly upon the incubation temperature and that the effect may either accelerate or retard subsequent transformation. In particular, transformation at 800° F. is severely retarded by incubation just above the bainite nose, that is, at 950° F. Thus the effect of incubation is not simply additive as assumed in the derivation of C-T diagrams.

Finally, results are presented to show that upon continuous cooling, which requires that the steel pass through temperature ranges where incubation retards or accelerates transformation, the lowest temperature zone prior to the beginning of actual transformation has the predominant influence. Since, upon continuous cooling to form bainite, this steel must pass through a temperature range where incubation significantly retards transformation

(1000 to 950° F.), the bainitic hardenability is higher than predicted by the derived C-T diagram.

The results described in the paper show that the effects of incubation upon austenite transformation are complex in this steel and suggest the need for a theory of solid-state transformation in steel which involves some sort of temperature-dependent change in preliminary to formation of stable nuclei of any new phase. Such a theory of austenite decomposition may be based upon heterogeneous rather than homogeneous nucleation.

JOSEPH F. LIBSCH

Properties of Heat Treated Uranium Alloy

Digest of "Properties of As-Cast and Heat Treated 2 Wt. % Molybdenum Uranium", by E. G. Zukas, Preprint No. 115, 1958.

THIS PAPER reports the mechanical properties which can be obtained by heat treating a uranium alloy containing 2.00 to 2.35 wt.% molybdenum and small amounts of carbon (90 to 160 ppm.), iron (50 to 200 ppm.), silicon (80 to 300 ppm.), and aluminum (10 to 60 ppm.). Starting with homogeneous castings 18 x 8 x 1¼ in., blanks were made which could be machined into V-notch Charpy impact and standard 1-in. gage length tensile specimens. The blanks were treated in vacuum (0.01 to 0.1 micron) before machining. Samples were tested in the as-cast condition and subjected to solution heat treatment at 850° C. (1560° F.), followed by various quenching and aging treatments. Testing temperatures used were −198, −80, −30, 20 and 100° C. (−320, −110, −20, 70 and 210° F.) Impact specimens, unnotched and with various notch sizes, were tested on a standard Sonntag impact machine and tensile results were obtained at a load rate of about 6000 psi. per min. Yield strengths were determined at 0.2% offset.

The maximum tensile strength was 229,000 psi. at a peak in the tensile strength-temperature curve at −30° C. (−20° F.) for a sample subjected to an 850° C. (1560° F.) solution treatment followed by water quenching and aging at 450° C.

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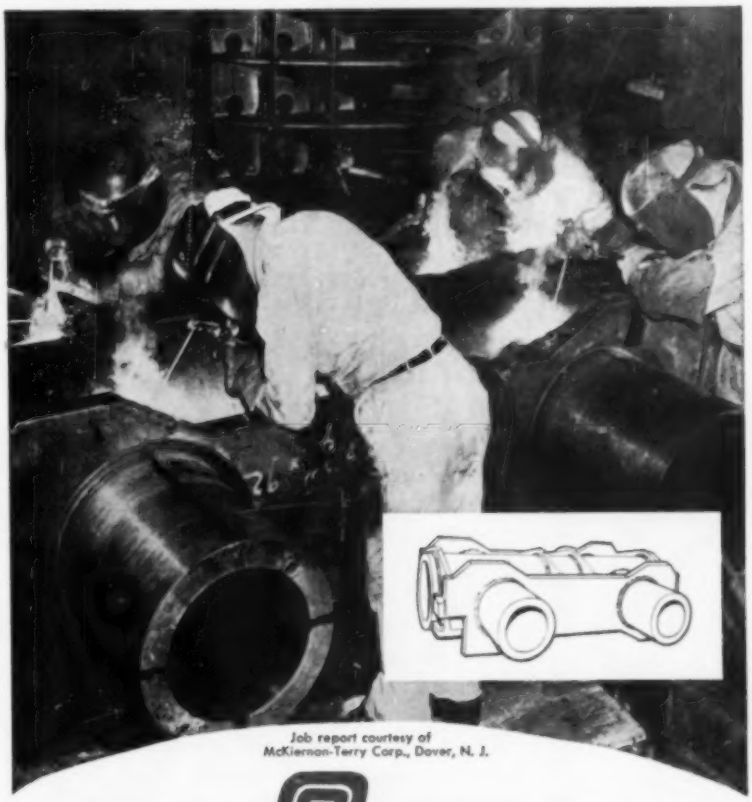

Job report courtesy of McKiernan-Terry Corp., Dover, N. J.

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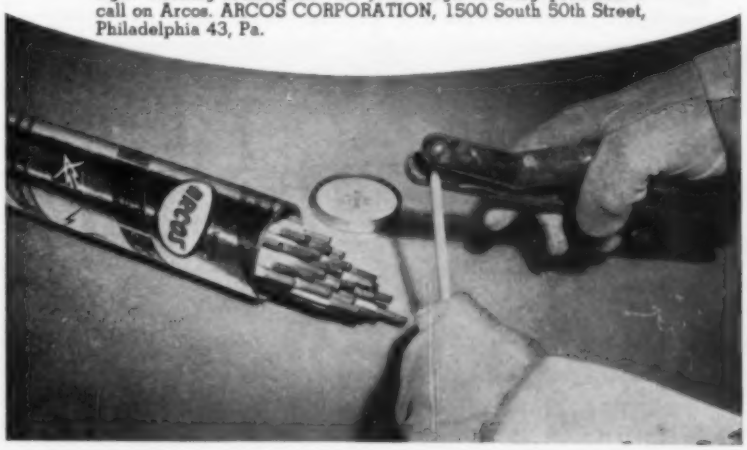

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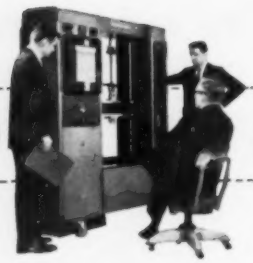

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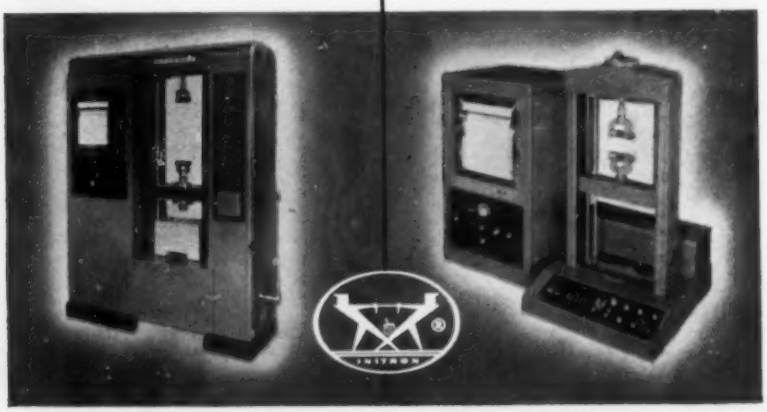

Uranium Alloys . . .

(840° F.) for 1 hr. All other heat treatments produced peaks in the tensile strength curves in the temperature range −30 to −80° C. (−20 to −110° F.) A peak in the yield strength curve occurred only with water quenching and aging. All other treatments produced higher yield strengths at the lowest temperatures. The water quenched and aged specimens had less than 1% elongation and failed in a brittle manner. Generally all specimens were brittle at the lowest temperature.

The better ductility values were obtained by quenching the specimens from 625° C. (1160° F.). The added ductility was accompanied by decreased tensile and yield strengths.

For application of this alloy within the temperature range studied, the homogenized and furnace cooled alloy was considered practical. Generous fillets and elimination of small radii notches are recommended if impact loading is an important factor. Such an alloy would have tensile strengths of 100,000 psi. at 120° C. (250° F.), 160,000 psi. at a peak near −80° C. (−110° F.), and 120,000 psi. at −200° C. (−330° F.). Elongation varied from 20% in 1 in. at 120° C. (250° F.) to 1% at −200° C. (−330° F.). Impact strength decreased from 23 ft-lb. at 100° C. (210° F.) to 2 ft-lb. at −200° C. (−330° F.). Yield strength ranged from about 70,000 psi. at 120° C. (250° F.) to 100,000 psi. at −200° C. (−330° F.).

W. R. Opie

Unique Deformation of Magnesium Alloys

Digest of "Unique Deformation and Aging Characteristics of Certain Magnesium-Base Alloys", by S. L. Couling, J. F. Pashak and L. Sturkey, Preprint No. 59, 1958.

Certain magnesium alloys have unlimited cold rollability. This paper describes two of these alloys in detail and gives the probable deformation mechanism operative in these alloys which accounts for their unusual behaviour.

The alloys discussed are magnesium plus 0.5% Th, and magnesium plus 0.2% misch metal plus 0.4%

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Deformation . . .

Zr. The properties of these alloys varied with the amount of cold reduction, and figures are given for reductions up to 87%. For example, the tensile yield strength (0.2% offset method) increases up to approximately 15% reduction and then slowly decreases. The mechanism proposed by the authors to account for the behaviour is as follows: Cold rolling work hardens the material in the normal manner up to a certain point and then bands form causing the yield strength to decrease. The bands are thought to be sections of material in which the basal plane is more favorably oriented for slip than in the rest of the material. Several mechanisms for the band formation are discussed, but the authors indicate that the results to date support a double twinning process; a [1011] twin forms first and the twinned material retwins on a [1012] plane.

The "softening" is not the only property of these alloys that the authors discuss, since in their own words "aging the cold rolled material at low temperatures raises the yield strength; the greater the rolling reduction the higher the yield strength in subsequent aging". It is proposed that the hardening mechanism is polyganization within the bands and the subsequent pinning of the walls by solute diffusion to the dislocations. No direct evidence is given for such a mechanism, but the authors feel that it does account for the observed phenomena.

Several experiments were carried out to show that the increase in yield strength during aging is not a simple precipitation reaction. For example, many experiments were done at temperatures where precipitation would not be expected, but nevertheless the increase in properties occurred. Electron diffraction studies indicated that the amount of second phase present did not increase during aging nor was any new precipitate present.

The paper contains six graphs which give the mechanical properties of the alloys as a function of the deformation and aging history. In addition to the graphs, there are four photomicrographs which show the important "band" structure upon which the properties seem to depend.

W. C. WINEGARD

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℞ 410-U	410	51410	5350B	A296-49T	MIL-S-16993A	05913T
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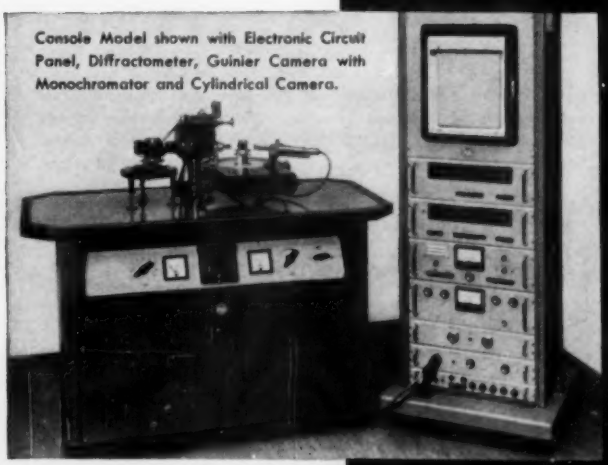
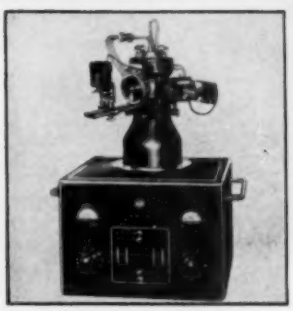


Console Model shown with Electronic Circuit Panel, Diffractometer, Guinier Camera with Monochromator and Cylindrical Camera.



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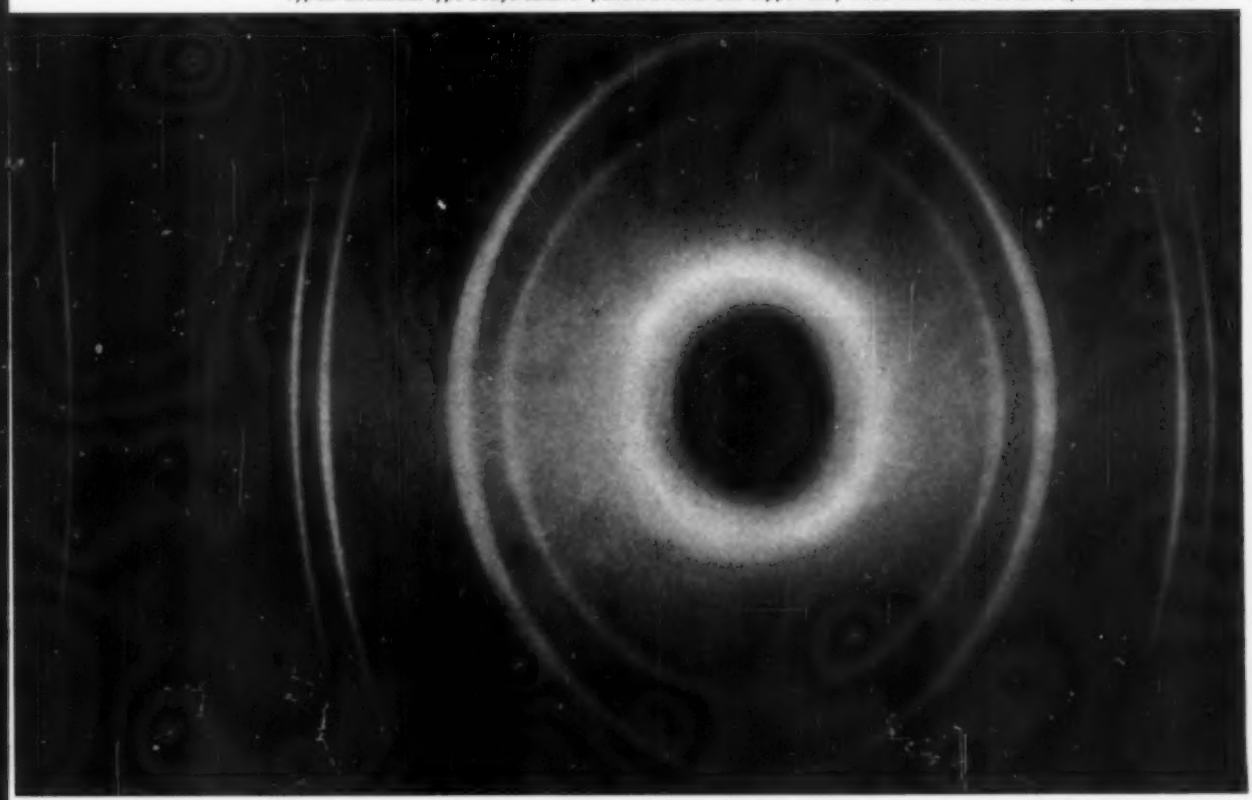

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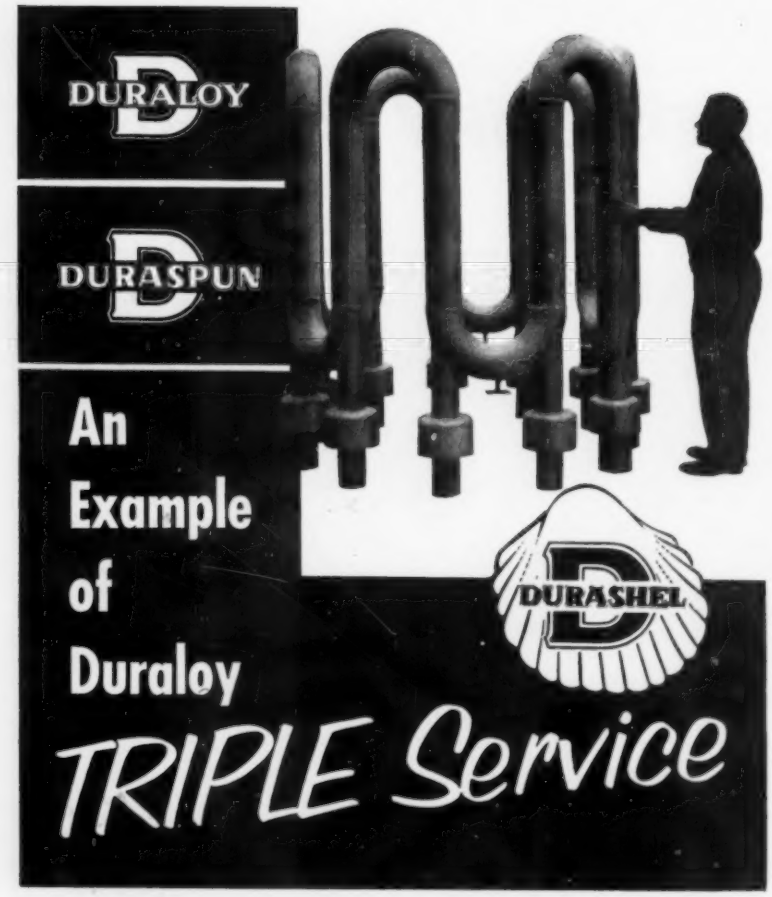

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Accelerated Creep-Rupture Testing

Digest of "A Procedure for Application of Time-Temperature Parameters to Accelerated Creep Rupture Testing", by S. S. Manson, G. Succop and W. F. Brown, Jr., ASTM Preprint, No. 106, 1958.

CONSIDERABLE INFORMATION has appeared in the literature regarding time-temperature relations for the correlation of creep-rupture data. Most previous investigations have evaluated the relative merits of the various parameters. However, very little information is available regarding experimental and analytical methods which permit full advantage to be taken of the potential savings in testing time offered by time-temperature parameters.

In this country particular attention has been given to the parameters proposed by Larson and Miller, Dorn, and Manson and Haferd. These three parameters have distinctly different forms, and require different assumptions regarding material behavior. The forms are:

LARSON AND MILLER

$$(T + 460)\ (C + \log t) = f\ (\sigma)$$

DORN

$$t \exp. - \frac{\Delta H}{R\ T_k} = f\ (\sigma)$$

MANSON AND HAFERD OR LINEAR

$$\frac{T - T_a}{\log t - \log t_a} = f\ (\sigma)$$

where T is the test temperature in ° F.; T_k the absolute temperature in ° K.; t the rupture time; C, T_a, log t_a, and ΔH are material constants assumed to be stress independent; R is the gas constant and f (σ) is a single-valued function of the applied nominal stress.

Isostatic tests offer the most direct means of evaluating the constants as well as serving as a check on the assumptions regarding material behavior. If nothing is known about the creep behavior of the material, several questions arise as to the best procedure for conducting the isostatic tests.

1. What stress or stresses are selected for the determination of the constants $\frac{\Delta H}{R}$, and Ta, log ta?

2. How are the temperatures of these tests chosen so that unduly

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Creep-Rupture . . .

long rupture times are avoided?

3. How are the temperatures for tests at various additional stresses selected to avoid either extremely long or very short rupture times?

The authors answer these questions by demonstrating a rational procedure designed to obtain the linear parameter master curve for a Cr-Mo-V steel "17-22-A" S. The main features of this procedure are also adaptable to the Larson and Miller or the Dorn parameter master curves. A further check on this procedure was possible using previously published isostatic data for an alloy of widely different composition, namely, Timken 16-15-6.

From the master curves, isothermals were calculated for both the "17-22-A" S and Timken 16-15-6 alloys. The comparisons between calculated results and experimental data permit conclusions both as to the validity of the proposed procedures for applications of parameters as well as to the relative ability of the various parameters to represent true material behaviours.

For both the "17-22-A" S and 16-15-6, the isothermals calculated from the linear parameters master curve agree well with the experimentally determined data. For "17-22-A" S, data at times well over 1000 hr. and, at 940° F., to 24,000 hr. have been predicted accurately from tests having a duration of not over 100 hr. Thus, it may be concluded that the basic procedure outlined for obtaining the parametric constants and master curve is valid.

Regarding a comparison of the parameters, both the Larson and Miller and the Dorn relations compromise the true material behaviour.

The authors outline a procedure for the use of the linear time-temperature parameter in obtaining isothermal creep-rupture data on an alloy for which no previous creep information exists. This procedure is free from the complexities of cross plotting and involves no more human judgment than is required in drawing curves through isothermal data. Furthermore, a great saving in time and equipment is possible through the use of such a method.

D. J. GIRARDI

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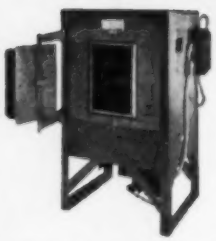

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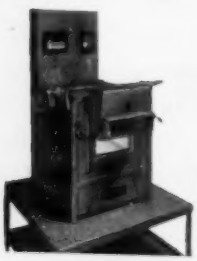

Bench Type: for tools and small parts—to 2000° F. 14 sizes to 10″ w. x 8″ h. x 18″ d.

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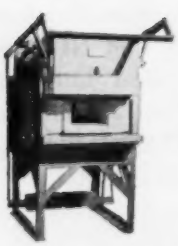

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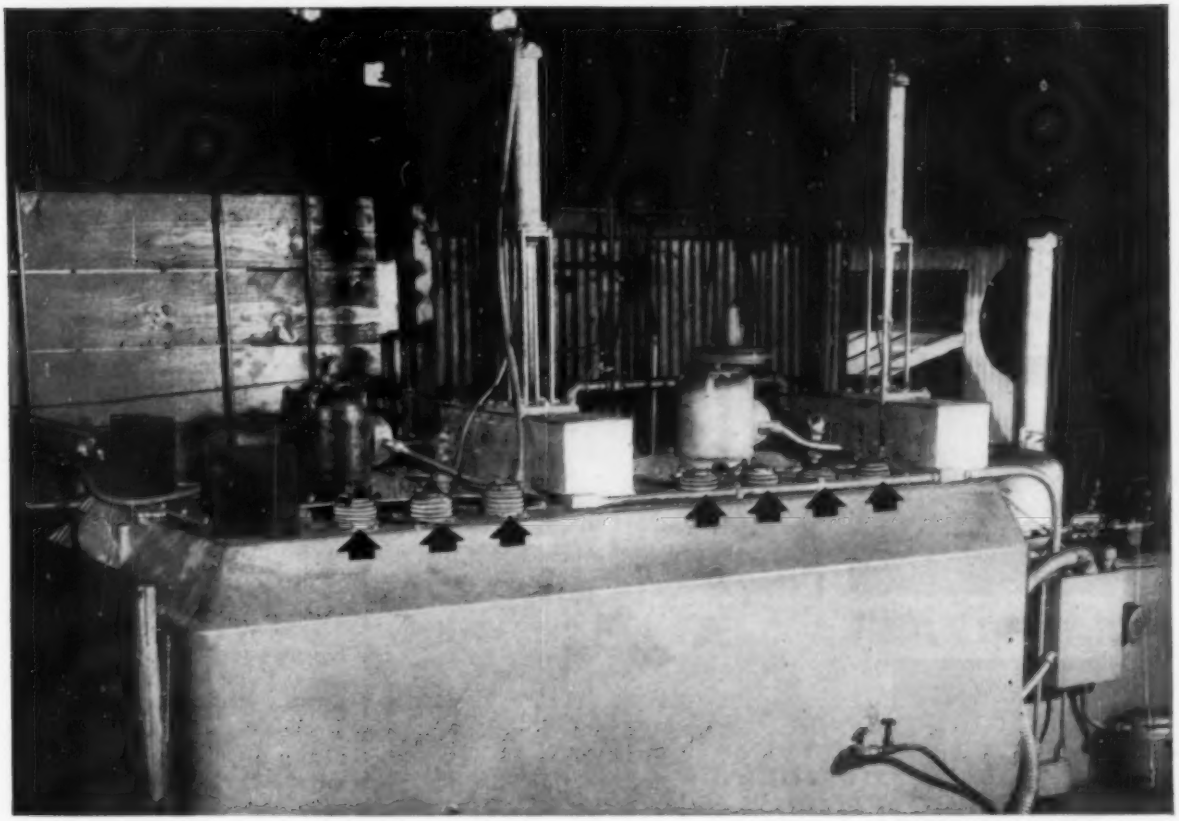
Columbium at Elevated Temperatures

Digest of "High-Temperature Oxidation and Contamination of Niobium", by W. D. Klopp, C. T. Sims and R. I. Jaffee, Preprint No. 64, 1958.

COLUMBIUM and its alloys have received considerable attention during the last few years as possible structural materials for jet engines and nuclear reactors. At room temperature, columbium develops only moderate strength; however, at elevated temperatures this strength does not fall off rapidly and at 1600 to 1800° F. the rupture strength is comparable to that of molybdenum. The major shortcoming of columbium is its low oxidation resistance; the oxide formed is not volatile below 2550° F. but apparently is not protective.

The reaction rates of columbium with pure oxygen between 1110 and 2190° F. were determined in a modified Sieverts apparatus. Cylindrical specimens were machined



Durable Inconel radiant tubes have replaced the original tubes in this furnace...have served well for over a year. Two more years are predicted.

How to get years instead of months— of service from your radiant tubes

The original radiant tubes in this furnace failed in a few months from physical and cyclic thermal shock.

The remedy... Security Engineering, Whittier, Cal., replaced with Inconel* nickel-chromium alloy tubes. Security made a change in burner control to maintain steady furnace temperature. The Inconel tubes are in good shape after almost two years at 1550°F. The heat treat superintendent predicts they'll last 2 more years!

And in two other "hot spots"—

Wrought Inconel furnace baskets, as shown in right hand photo, carry parts through heating and oil quenching, give an average of 6 months' service.

Wrought Inconel carburizing containers are going strong after a year – they weigh 200 lbs, carry 1000 lbs of parts through 1600°F pit carburizing and subsequent oil quenching.

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Inconel alloy is at home in a great variety of furnace and heat treating applications... wherever you need high temperature strength, resistance to corrosive attack and thermal shock. Ask your fabricator to quote on Inconel radiant tubes, baskets, other "hot spot" equipment for your shop.

*Registered trademark

The International Nickel Company, Inc.
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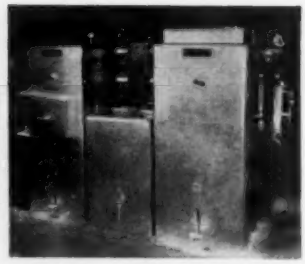
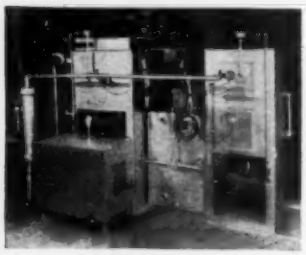
Worker charges furnace with Inconel basket containing drilling heads. Basket gives about 6 months' service.

INCO NICKEL ALLOYS



Front view—double-chamber furnace on the left; control board and quench tanks, center; globar-heated furnace on the right.

heat-treating is profitable with new Waltz 3-unit small-tool furnaces



Rear view, showing the globar furnace on the left.

View of a globar furnace with water-cooled chamber, cooling system in the rear.

Furnace—furnace—quench tanks (side-by-side) positioning.

Furnace—quench tanks—furnace (side-by-side) positioning.

Furnace—quench tanks—furnace (corner) positioning.

Cost-conscious manufacturers are increasing their profits by doing their own small tool heat-treating with a new Waltz small-tool furnace. This modern, three-unit set up provides the wide temperature ranges and accurate controls needed to heat-treat all types of steels, including the cobalt type, right in your own plant.

The three units consist of a drawing furnace of the recirculating type installed beneath a preheat furnace; oil, and water quench tanks; and a globar-heated, high-temperature furnace. There is an atmosphere generator for supplying atmosphere to the preheat and high heat furnaces. The water-cooled chamber at back of globar furnace is optional equipment. It permits cooling of parts in controlled atmosphere.

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Columbium . . .

from arc-melted buttons. The reaction at 1110 to 1830° F. proceeded linearly within experimental error; however, at 2010° F. the rate increased sharply. The oxide formed at the lower temperatures was white and powdery, while at higher temperatures it formed as slabs. X-ray diffraction showed the scales formed at 1110 and 1830° F. to be T type and M type Nb_2O_5, respectively. A thin black subscale was found on the surface of the reacted metal samples which was identified as oriented Nb_2O_5 and NbO. In neither scale nor subscale was NbO_2 found.

The effect of oxygen pressure was also determined at 1470° F. using oxygen pressures of 76, 38 and 7.6 cm. At 76 and 38 cm. the reaction rates are practically linear, but at 7.6 cm. the curve was parabolic and less oxygen was consumed. At 76 cm. the scale was primarily Nb_2O_5 with a very thin subscale. As pressure was decreased, the Nb_2O_5 layer decreased and the subscale thickness increased. Correlation of the subscale thickness with reaction rates at various pressures were inconclusive. The authors feel that the oxygen must diffuse through the subscale during oxidation.

The reaction between columbium and nitrogen is very slow up to 1830° F. Using the modified Sieverts apparatus, no reaction was detected at either 1470 or 1830° F.

In the air investigation, either arc-melted specimens or swaged vacuum-sintered rods employing intermittent weighing were used for oxidation tests. Tests were run between 1110 and 2190° F. with results being lower than for oxygen. This is apparently the result of lower oxygen content in air. Nevertheless, the reaction rate processed at a linear rate but at 1830° F. was slower than would be expected. This could be accounted for by moisture in the air or the sintering of the oxide to produce a more protective scale.

Contamination of columbium was attributed to oxygen diffusion with a negligible contribution from nitrogen diffusion. The diffusion coefficients for oxygen in columbium were calculated from the data and a value of 24,900 cal. per mole obtained for the activation energy for diffusion.

R. D. CHAPMAN

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Ductile to Brittle Transition of 1020 Steel

Digest of "Some Low-Temperature Observations of 1020 Steel", by F. S. Deronja and M. Gensamer, Preprint No. 87, 1958.

THIS INVESTIGATION covers the ductile to brittle transition (transition temperature) in an S.A.E. 1020 steel. As pointed out in the paper, the usual method of studying this transition temperature is by means of a notched bar. However, the use of such a specimen reveals little concerning the variation of the fundamental properties as the temperature is lowered because the strain is not uniformly distributed in the plastic region. Therefore, for this study a 3-in. long tensile bar was employed. Rather than having the normally reduced section, these investigators used a round specimen whose gage length was produced by machining to a 3½ in. radius with a minimum diameter of 0.090 in. Such a test bar has a gage length which is uncertain, varying from 0.1 to 0.4 in., being determined by the length over which twinning occurred on slow stretching. These tensile bars, after careful polishing, were capsulated in quartz tubes and heat treated to produce grain sizes of A.S.T.M. 4 and 6.

The specimens were tested above 20° K. in a hydrogen cryostat tensile machine with special precautions to insure alignment. When testing temperatures below liquid nitrogen were used, the expansion of high-pressure cylinder hydrogen was employed being precooled with liquid nitrogen. For temperatures below 20° K., a helium cryostat was used.

Graphic results are shown for the effect of temperature on fracture stress, yield stress and reduction in area. The authors choose to call the transition temperature at a point corresponding to 2.5% ductility. Several reasons are given for this choice: It was the least amount of ductility present at the lowest testing temperature in A.S.T.M. 6, etch pits revealed fractures below this point were essentially cleavage, and the value coincides closely with those obtained by the intersection of the upper yield stress and brittle fracture stress curves. Test results indicate that an increase in grain

How to measure

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A continuous furnace is more than just a brick-lined structure built to heat a material; it is a processing tool.

Like all processing tools, it must be evaluated on an overall basis. Fuel consumption and efficiency may be completely outweighed by many more-important economic factors centering around your workpiece, your total production program, and your work force.

Your evaluation may well prove that an investment now in Selas continuous heat processing will bring immediate returns in reduced costs and improved product quality.

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- **Temperature control**
- **Work in process**
- **Product value**
- **Fuel efficiency**
- **Production requirements**
- **Flexibility**
- **Process coordination**
- **Floor space**

The factual report on the facing page tells how a manufacturer of business machines took this long, hard look at one phase of its electric typewriter production. Every evaluation factor proved significant: two factors combined to represent savings which equalled the cost of the Selas custom-built equipment in less than one year!

See Selas Heating in Action at the Metal Show Booth 1924

the real cost of continuous heat processing

. . . here's how one SELAS heat treating installation stands up under that "long, hard look!"

For dependable performance, electric typewriters require hard, tough, perfectly flat type-bars. By a previous method, hardness and toughness were imparted to the steel stampings but the flatness left something to be desired.

This Selas heat processing machine produces hardness, toughness and flatness never before actually achieved!

Former equipment included two open salt baths, hazardous even in day-to-day operation; particularly dangerous during the monthly clean-out of carry-over sludge.

The Selas equipment uses a single covered salt bath which has completely removed both of these hazards.

Material Saving

Selas direct heating eliminates the high temperature salt bath thus preventing contamination of the salt quench. Salt savings have been estimated by Selas engineers to amount to $25,000 per year.

Labor Requirements

Three men do the work previously performed by five . . . a labor saving of 40%. In a continuous 2-shift operation, annual savings can amount to as much as 26% of the original equipment cost. These savings might very well be doubled by fully-automatic loading now being developed.

Automatic Operation

Type-bars are conveyed automatically through the high temperature Gradiation® furnace, the salt quench, the washer and the dryer.

Material Handling

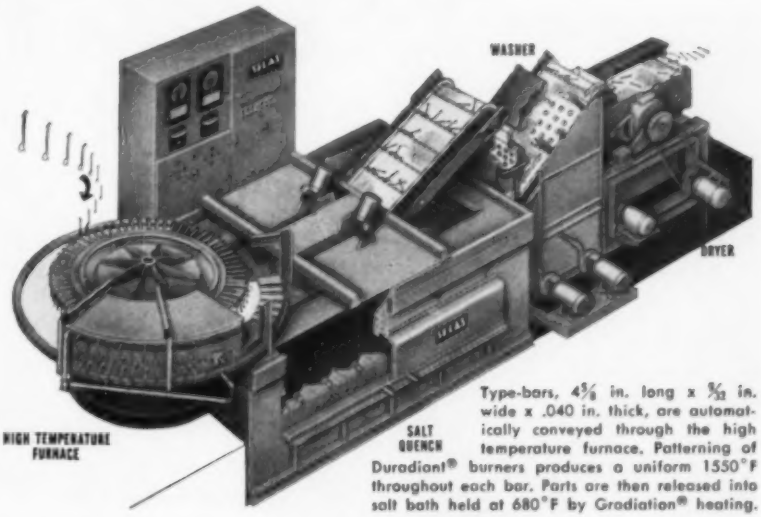
The compactness and simplicity of the Selas unit have eliminated the need for dip-type fixtures. Instead of being transported through the plant to a separate heat treating department, parts are loaded from the adjacent stamping press to pass automatically through the several processes embodied in this one Selas machine —and are delivered for final tumbling and plating at the discharge end of the unit.

Maintenance

Because racks and extra fixtures are not required and salt pot cleaning is reduced to a safe, routine operation, maintenance costs are substantially less.

Human Element

Custom-built precision and automatic operation avoid variations due to human handling. Top production of uniformly austempered type-bars is consistently achieved.



Type-bars, 4⅝ in. long x 5/32 in. wide x .040 in. thick, are automatically conveyed through the high temperature furnace. Patterning of Duradiant® burners produces a uniform 1550°F throughout each bar. Parts are then released into salt bath held at 680°F by Gradiation® heating.

Product Quality

Type-bars austempered in this machine meet specification for flatness of 0.001 in. and for hardness of Rc 42-44.

Temperature Control

Furnace temperature, salt quench temperature and dryer temperature are automatically controlled from the convenient cubicle supplied by Selas.

Work in Process

Previous batch method consumed hours. This Selas continuous heat processing equipment heats conveyorized type-bars in 25 seconds, holds them in the salt bath for 15 minutes, cleans and dries them . . . a total of 21 minutes for the entire, complex austempering process.

Product Value

Value of the product as it is passing through this machine in a few hundred hours equals the customer's entire investment in the Selas custom-built equipment.

Fuel Efficiency

Fuel cost amounts to about 1 hour of the 320 hour monthly production.

Production Requirements

The Selas machine is capable of uniformly austempering 5,000 type-bars per hour.

Flexibility

Any of a number of similar metal stampings can be processed in this versatile machine. The customer has since purchased a second Selas machine to austemper cam levers at production runs of 6,000 per hour, as well as type-bars.

Process Coordination

The Selas machine, developed cooperatively by the customer's and Selas' engineers, was designed to fit into the production area, completely integrated with the normal production schedule of the electric typewriter manufacturer. All equipment, including panel-mounted combustion and temperature controls, was built at Selas. Selas engineers supervised start-up in customer's plant.

Floor Space

The compact unit occupies about half the floor space occupied by previous equipment. With all the heat directed into the workpieces—not the work area —adjacent floor space can be utilized efficiently.

* * *

For further information on this installation, send for reprint "Automatic and in the Line." For case histories covering other heat treating operations, heating for hot working, and brazing, send for reprint "An Economic Appraisal of Continuous Heat Processing." Address Dept. 310, Selas Corporation of America Dresher, Pa.

Gradiation and Duradiant are registered trade names of Selas Corporation of America.

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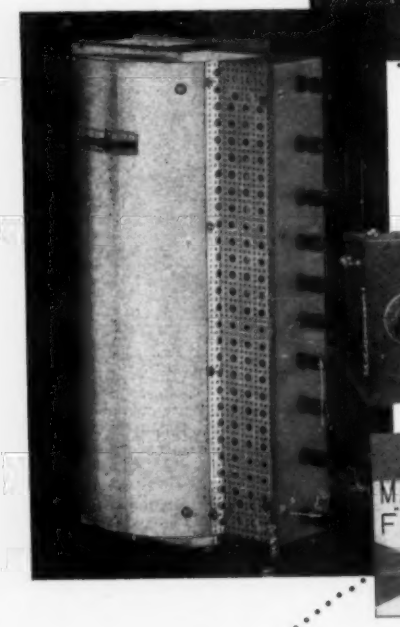

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Transition . . .

size by two A.S.T.M. numbers lowers the transition temperature by about 20° C. (68° F.).

Tests were also conducted on the effect of changing the testing speed. Using the same criterion for transition temperature as for the grain size study, it was found that increasing the testing speed one hundred fold (0.1 to 10 in. per min.) resulted in raising the transition temperature about 10° C. (50° F.).

Metallographic examination indicated that the primary mode of deformation below the transition temperature in coarse-grained steel was twinning. With finer-grained steels, twinning assumes a smaller role and slip contributes a greater part to the observed ductility. Further, as the testing temperature is lowered, the fracture stress starts to decrease at the temperature at which twins are first observed. Finally, the authors observed that twinning precedes crack nucleation and propagation in the brittle range and above the transition temperature can occur before yielding.

R. D. CHAPMAN

Strain Hardening in Aluminum

Digest of "Temperature and Rate Dependence of Strain Hardening in the Aluminum Alloy 2024-0", by D. S. Fields, Jr., and W. A. Backofen, ⊜ Preprint No. 61, 1958.

IN PRACTICAL APPLICATION strain hardening relationships influence such important commercial considerations as the permissible working temperatures and rates, size of equipment required in metal working operations and range of useful service temperatures and stresses for metals and alloys. The objectives of the more fundamental studies have been to evaluate the competitive roles of strain hardening and recovery over a range of temperatures and rates, and thus contribute a better understanding of the mechanisms and kinetics of deformation and recovery.

In this paper the strain hardening characteristics in shear of the commercial aluminum alloy 2024-0 are presented for a wide range of temperatures, −195 to +500° C.

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Plume & Atwood manufactures pen caps, pen barrels and lipstick cases by the million to their exceptionally rigid quality specifications. But the high luster buffed into these parts was being lost in the degreaser. Tarnished spots suddenly started to show up, making a good coating job impossible.

(This is a fairly common problem in vapor degreasing. It's caused by the solvent you use turning acid. Solvent can go sour rapidly–unless it's protected by a neutral stabilizer that doesn't lose strength.)

Plume & Atwood tried several different conventional degreasing solvents, without success. Results were "inconsistent"; solvent life was much too short. To keep the bath from going sour, P and A had to dump and clean out the degreaser *every three weeks.*

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Then P and A switched to NIALK TRICHLORethylene. Result: immediate improvement. The first charge of NIALK solvent functioned without trouble for *nine weeks.*

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"We're getting considerably better solvent mileage," says John Bradford, P and A's assistant to the plant manager, "and much improved gloss and luster at lower cost–thanks to NIALK!"

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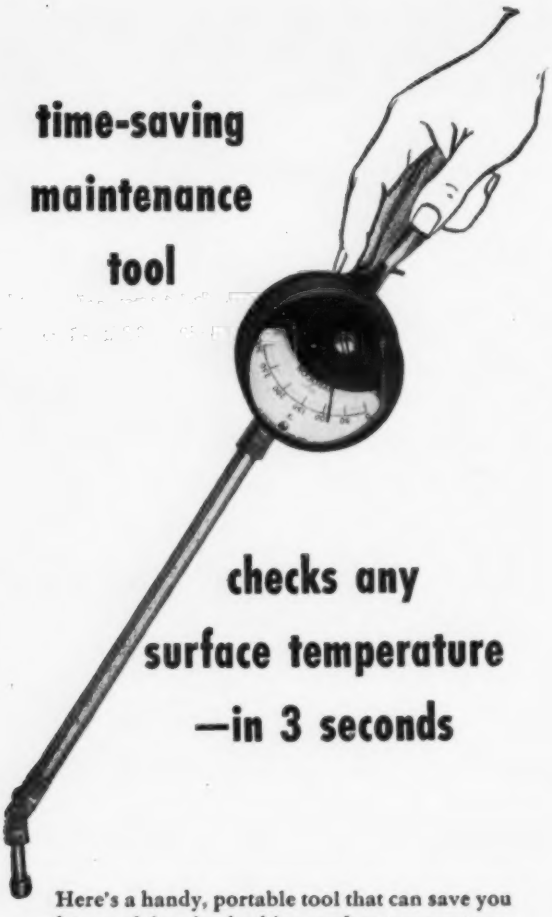

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Aluminum . . .

(−320 to +930° F.), strains and strain rates. The data were obtained using the technique of differential torsion testing in which two solid torsion specimens of differing radiuses are tested and the torque difference between the two is taken as that which would apply to a tube. In this manner, instability problems inherent in testing tubes at large torsional strains and the complications of shear strain variations in solid specimens were avoided.

Over the relatively small range of strains for which data on other aluminum alloys are available, the strain hardening characteristics of 2024-0 resemble those of the other alloys with respect to temperature and rate effects. At temperatures below 200° C. (390° F.), flow stress values are considerably less affected by temperature and strain rate than at higher temperatures. The existence of the low-temperature region of low strain rate and temperature sensitivity and the observation of discontinuous yielding in the tests were evidence of strain aging.

The presence of strain aging and the possible effects of variation in solid solubility of alloying elements with temperature in the commercial alloy interfered with a simple analysis of the behavior in terms of relative strain hardening and thermal softening. However, in the high-temperature low-stress region calculated activation energies in the Zener-Holloman parameter were found to be nearly equal to the activation energy for self-diffusion of aluminum, and this was interpreted as indicating that recovery takes place simultaneously with deformation under these conditions.

The Zener-Holloman parameter was not generally applicable to the data and the deviation from more simple behavior was attributed to the interference of strain aging and metallurgical changes occurring over the wide range of temperatures investigated. This is typical of the difficulty often encountered when a complex commercial alloy is employed in fundamental studies.

It is noteworthy that maximum strains before fracture in the torsion tests were observed at 350° C. (660° F.) which is in the vicinity of the hot working temperature range for

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Aluminum . . .

the alloy. In the tests performed at 200° C. (390° F.), mechanical instability resulted in a concentration of deformation at the center of the gage length. This was attributed to the formation of a slight longitudinal thermal gradient in the specimens. At this temperature, the gradient could cause a relatively significant variation in flow stress thus promoting localized overstrain. An unexplained initial yield effect was observed at temperatures of over 425° C. (800° F.), at all strain rates. Further investigation would be needed to clarify factors responsible for this effect.

H. Y. Hunsicker

Titanium in Fuming Nitric Acid Environment

Digest of "The Corrosion, Pyrophoricity, and Stress-Corrosion Cracking of Titanium Alloys in Fuming Nitric Acid", by John B. Rittenhouse, ⓜ Preprint No. 68, 1958.

The corrosion behavior of titanium and commercially available titanium alloys in fuming nitric acid depends upon the relative amounts of H_2O and NO_2^+ ions present in the solution. Consideration of the chemistry of the HNO_3-NO_2-H_2O system and corrosion characteristics observed leads to the conclusion that the rate-determining factors are the concentrations of NO^+ and NO_2^+ ions in the solution. In the temperature range 25 to 71° C. (77 to 160° F.), the corrosion rates increase with increasing NO_2^+ and decrease with increasing H_2O. The corrosion product removed from the surface of commercially pure titanium after exposure to anhydrous fuming nitric acid was found by X-ray diffraction and chemical analysis to be titanium metal. The white residue obtained by vacuum evaporation of fuming nitric acid after storage of commercially pure titanium was found by chemical analysis to be of the form $TiO(NO_3)_2 \cdot XH_2O$. Metallographic examination indicates that a probable mechanism of attack of the fuming nitric acid on titanium and titanium alloys is through intergranular corrosion of either the all-alpha or all-beta phase. In mixed alpha-beta alloys, some indications of a possible galvanic mechanism of attack by the acid were noted.

The corrosion-time curves of commercially pure titanium in anhydrous fuming nitric acid (20% NO_2) follows a power function with a time exponent of less than 0.5 which is independent of temperature in the range of 77 to 160° F. This behavior indicates the possibility of borderline passivity. The corrosion-time curve of 92% Ti, 8% Mn alloy in the same medium also follows a power function during the first 30 hr. of exposure, but the time exponent is greater than 0.5 indicating the formation of a semipermeable coating of limiting protective value. The time exponent is again independent of temperature between 77 and 160° F. Beyond 30 hr. of exposure at 77° F. the corrosion-time curve becomes linear, whereas at 130 and 160° F. the corrosion behavior in the latter stages of corrosion are not explainable by any single mechanism.

Ignition and pyrophoric reactions of titanium and its alloys are directly dependent upon the presence on the surface of a dark coating which has been identified as finely divided titanium metal. The ignition can be initiated by impact or friction after exposure to fuming nitric acid containing from 0 to 1.25% H_2O and from 2.5 to 28% NO_2^+ for periods of time exceeding 4 hr. The violence of the pyrophoric reaction increases with increasing storage time and temperature and varies somewhat

(*Continued on page 226*)

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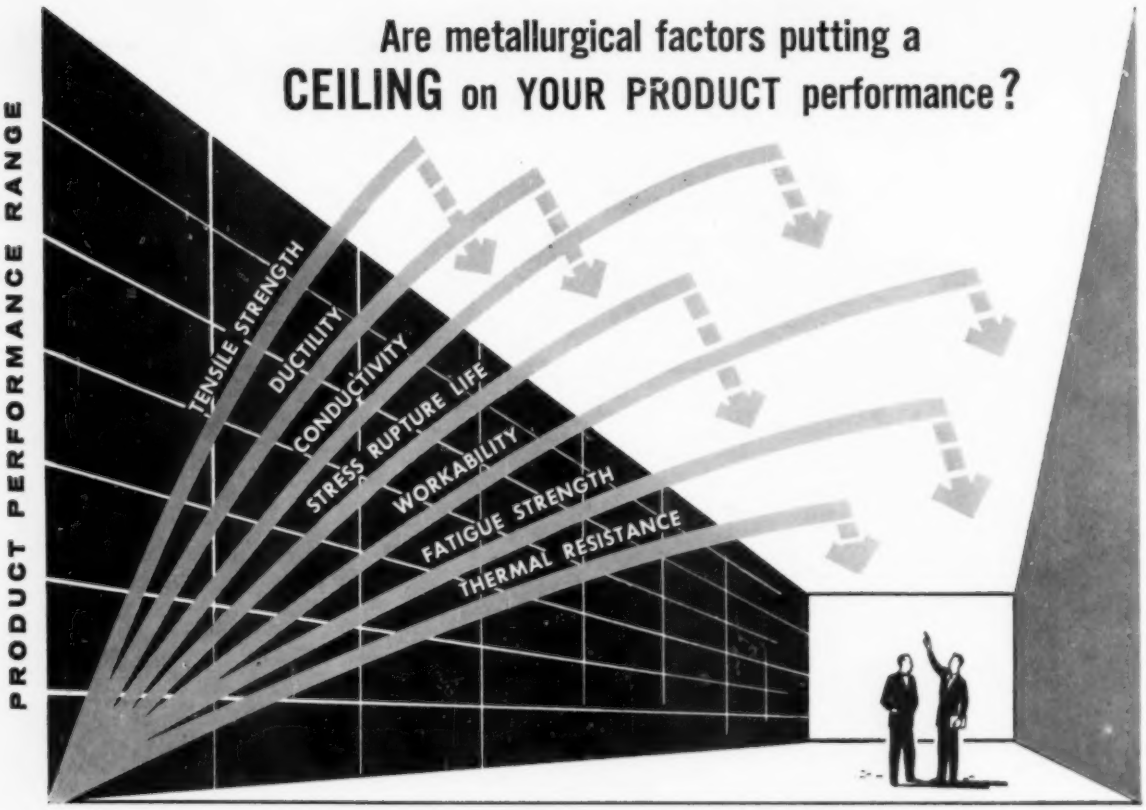

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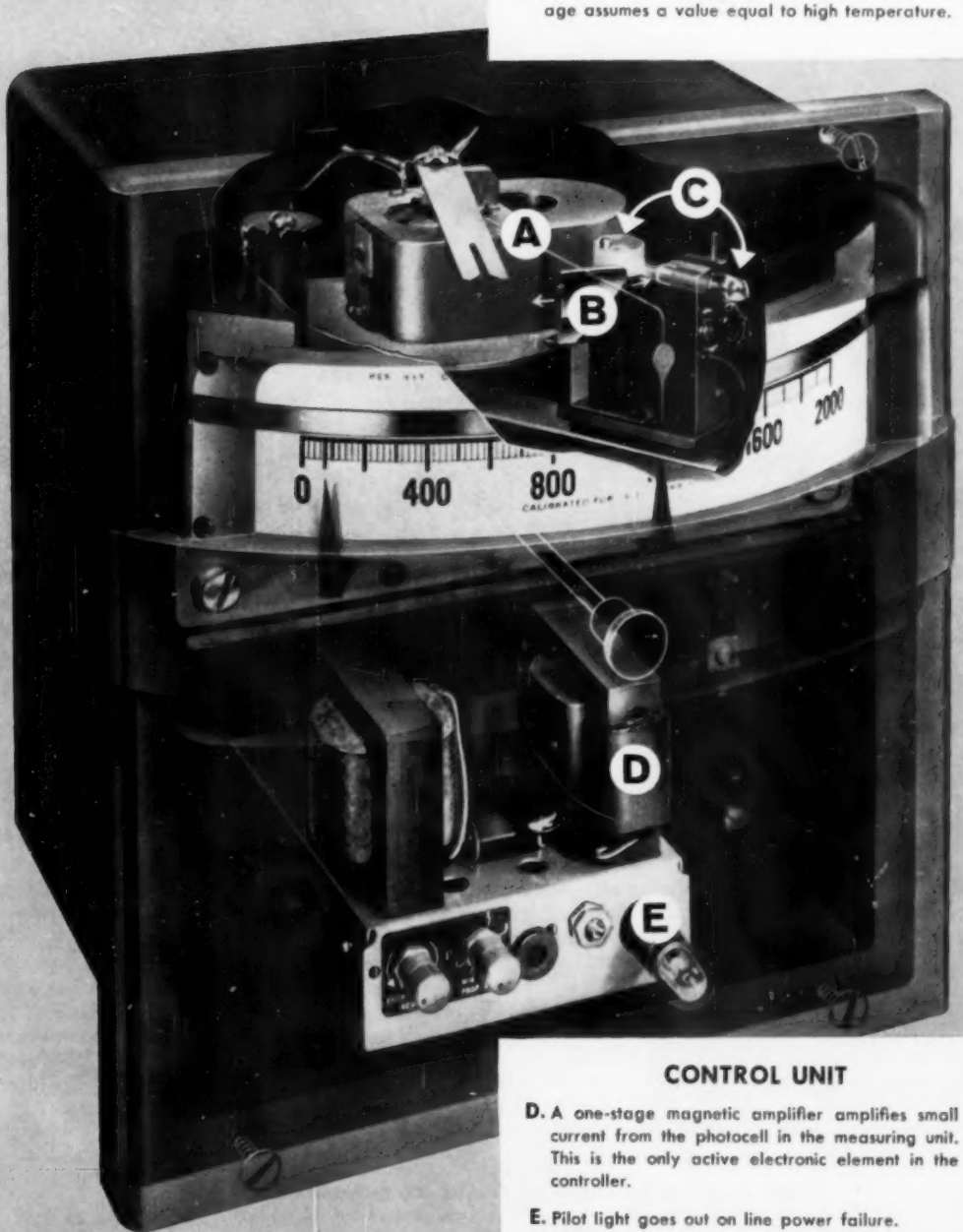

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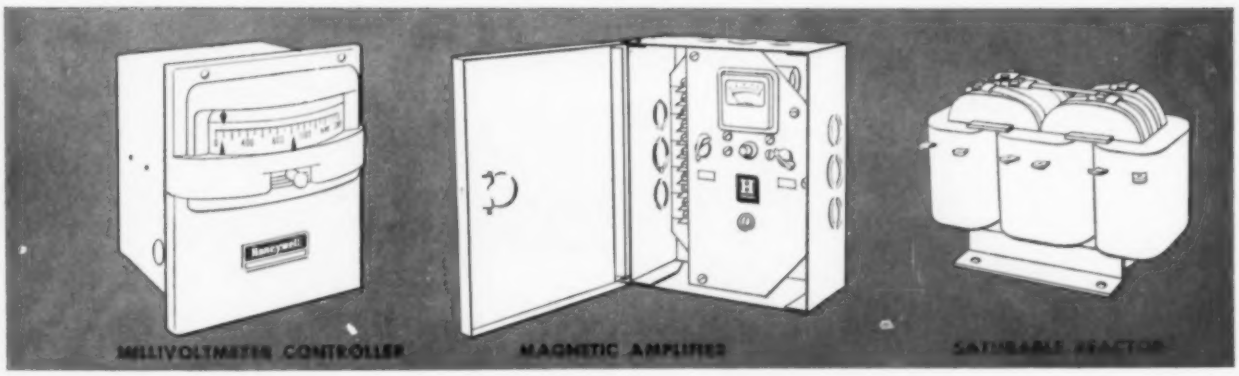

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Fuming Nitric Acid . . .

with alloy content. It has been shown that after 30 and 90-day laboratory storage no pyrophoric reactions were noted when the H_2O content of fuming nitric acid exceeded 1.3% (0 to 20% N_2O).

The tendency for stress-corrosive cracking also increases with increasing NO_2^+ content in the range from 0 to 28% and decreasing H_2O content in the range of 0 to 1%. Stress-relieving heat treatments reduce the stress-corrosion tendency.

The effects of longer than 90-day storage periods were not studied. Similarly, the effects of crevices or fabrication stresses on the corrosion, ignition tendency, or stress-corrosion cracking of titanium alloys in commercial fuming nitric acid were not investigated. It is strongly recommended by the author that considerable care be exercised in the use of titanium alloys in fuming nitric acid applications until the user has satisfied himself of the suitability of the material by long-term testings of fabricated components in the fuming nitric acid of intended use.

T. E. LEONTIS

Ductility of Austenitic Stainless Alloys

Digest of "Low-Temperature Embrittlement of Austenitic Cr-Mn-N-Fe Alloys", by F. W. Schaller and V. F. Zackay, Preprint No. 109, 1958.

THE AUTHORS investigated Cr-Mn-N-Fe austenitic stainless steels of the following composition:

CODE	CR	MN	N
D-1	14.20	14.38	0.058
D-2	14.13	14.49	0.091
D-3	14.20	14.54	0.13
D-4	14.32	14.16	0.29
D-5	14.24	14.49	0.36
D-6	16.44	14.53	0.49

The carbon content was between 0.02 and 0.03 for all alloys.

Ductility was studied as a function of temperature, strain rate, and interstitial content. Reduction in area was taken as the measure of ductility. Temperature varied between 100 and −196° C. (212 and −320° F.), and strain rates ranged between 0.002 and 12,000 in. per min. The latter strain rate was obtained by using an impact testing machine. The amount of martensite formed during plastic deformation was measured by magnetic means.

The influence of interstitial content on ductility is interpreted by considering two effects. The interstitials lower the M_s temperature. Lower temperatures must be employed to obtain the same amount of martensite for the same amount of deformation. The second effect is an increase in ductile-to-brittle transition temperature with increasing interstitial contents.

Accordingly, the alloys with low interstitial contents will form appreciable amounts of martensite during deformation even at room temperature, but this martensite will have a very low transition temperature and will therefore be ductile over nearly the whole temperature range. As the interstitial content

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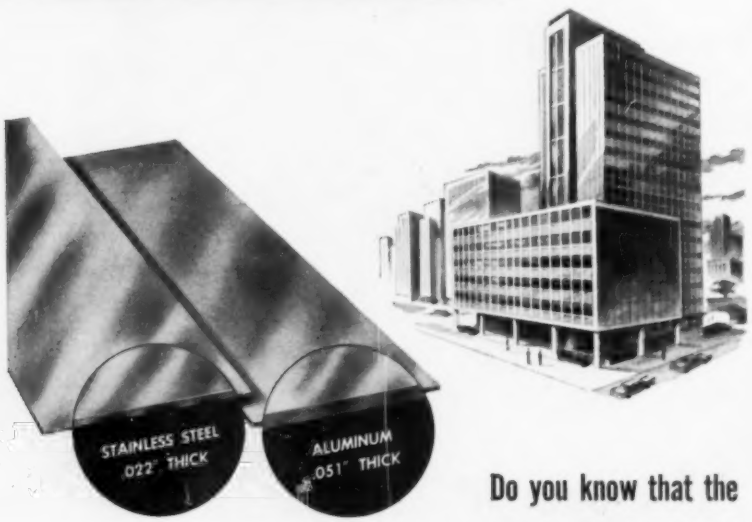

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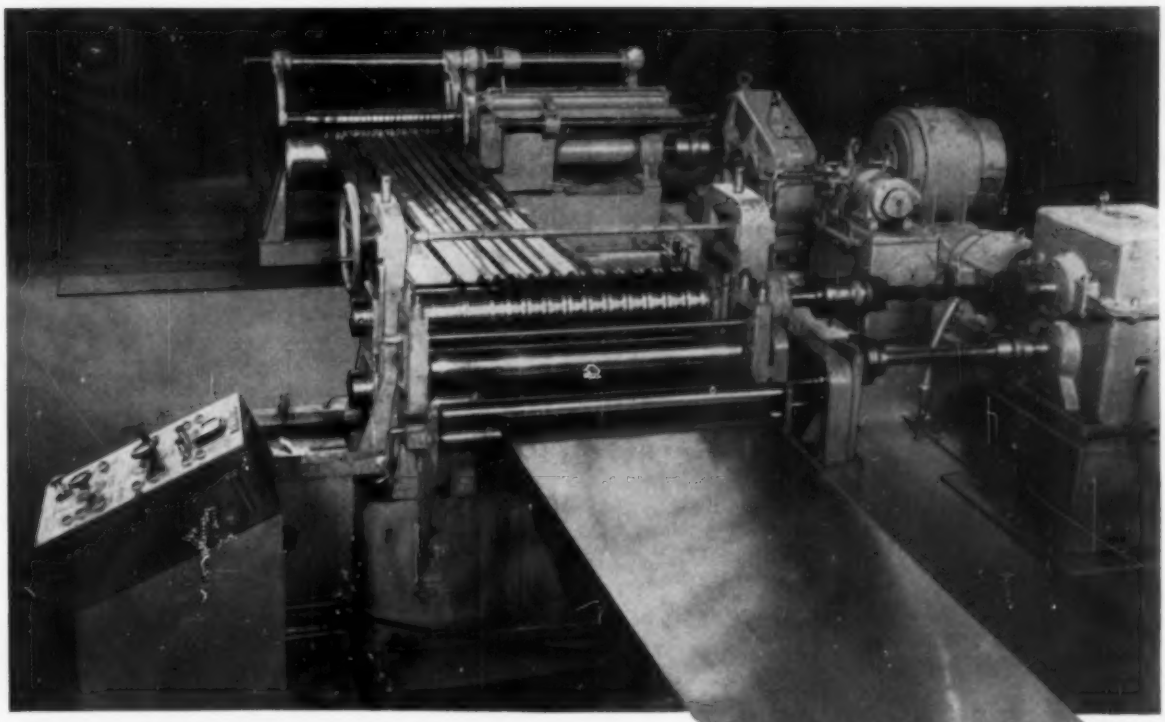

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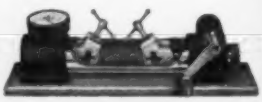

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Stainless Steel . . .

increases, the transition temperature for the as-formed martensite is raised and the alloys are brittle over a large range of temperature. At high enough interstitial levels, however, the M_s becomes the important factor and the effect of temperature upon ductility is reversed. Thus, a steel with 0.49% Ni becomes brittle at a lower temperature than a similar steel with 0.36% Ni.

The effect of crosshead speed on ductility is relatively minor for alloys with the lowest interstitial contents. For an alloy with 0.13% Ni, on the other hand, tested at −160 and −196° C. (−256 and −320° F.), the authors find low ductility at low crosshead speeds, but above a certain value of the strain rate, the ductility increases to a constant and high ductility value. The lower the testing temperature, the higher is the threshold speed. When the nitrogen content is increased, this phenomenon takes place at increasingly higher temperature.

The authors believe that the effect is due to localized heating in the necking area. Temperature measurements with thermocouple soldered to the specimen show an appreciable temperature rise at the same crosshead speed at which the ductility increased from a low to a high value. This experiment strongly supports the authors' idea of localized heating.

KURT M. CARLSEN

Brittle Fracture Propagation

Digest of "Cleavage Step Formation in Brittle Fracture Propagation", by J. M. Barry, Preprint No. 57, 1958.

FRACTURE SURFACES are quite varied in appearance. A study of the crystallographic features of these surfaces in silicon iron led to a further understanding of brittle fracture propagation.

Single crystals of silicon iron were fractured by driving a wedge into a notch at one end of the crystal at −196° C. (−320° F.). Since it was not possible to initiate fracture at room temperature, in some instances restraining blocks were used to stop the propagating crack. The

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blocks were then removed and the specimen allowed to come to room temperature, when the crack could be restarted.

Because it is impossible to avoid very high normal stresses to a single cleavage plane, fracture starts at a number of relatively widely separated levels at the base of the notch. As these cracks propagate laterally, they tend to join up by forming "cleavage steps". As the fracture propagates longitudinally, the difference in height can be reduced by running together steps of different signs. This results in the "river pattern" appearance of fracture surfaces. Fracture surfaces created by cleavage at 25° C. (77° F.) and —196° C. (—320° F.) appear to be qualitatively similar.

The main cleavage plane is made up of many different levels, but only one orientation. The levels are connected to each other by cleavage steps, which may be brittle, formed by cleavage on the (100) or (211) type of planes, or ductile, formed by a shearing-off process. Cleavage on the (211) type planes occurs only if these planes form a twin-parent crystal interface.

Cleavage step formation by the shearing-off model was not observed. However, since much of the detail of the river pattern was not resolvable, it seems possible that this mode of step formation could be quite common when the level differences are small. Electron microscope photographs showed that both crystallographic and noncrystallographic features were present.

It was observed that the overlapping of two cracks, on two different planes, would pull up a flap of material between them. A twin would then form in the flap, presumably due to plastic deformation, with the eventual result that the flap would fracture along the twin-parent crystal interface.

From a study of the appearance of cleavage steps on the fracture surfaces and on the fracture profiles at increasing distances from the sawed notch, it was observed that the geometry of the steps was the same, regardless of size, and that the step height decreased.

It was apparent from crystallographic arguments and metallographic observation that true cleavage can occur on twin-parent crystal interfaces during fracture propaga-

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Brittle Fracture . . .

tion. While such cleavage facets are parallel to (211) type planes, it would probably be unwarranted to infer from this that (211) type planes are cleavage planes in the same sense that (100) type planes are. Several unsuccessful attempts were made to start and propagate a fracture in a specimen so oriented that the stresses at the base of the sawed notch were normal to a (211) type plane.

The reason that cleavage can occur along the twin-parent crystal interface is presumably that this interface is already strained a certain amount. It can be shown that cleavage will relieve that strain.

Models to describe the formation of cleavage steps can assign to plastic deformation three quite different roles. First, it can be described as playing a continuous and terminal role in connecting cracks on different levels either by plastic necking off of flaps, or by plastic shearing off. Secondly, it is proposed here that plastic deformation forms of twinning can create a new type of cleavage plane, the twin-parent crystal interface. Finally, plastic deformation has been considered to be the means by which fracture is initiated on cleavage planes.

DEREK WALTON

Binary Columbium Alloys

Digest of "Studies of the Oxidation and Contamination Resistance of Binary Niobium Alloys", by Chester T. Sims, William D. Klopp and Robert I. Jaffee, ⊕ Preprint No. 70, 1958.

WHILE COLUMBIUM has considerable potential as a high-temperature structural material, the oxidation resistance of the pure metal is quite poor, a failing which is common to all the refractory metals. Unlike molybdenum and tungsten, the high-temperature oxide of columbium, Cb_2O_5, is essentially nonvolatile at temperatures up to 1200° C. (2190° F.), hence the possibility of improving the oxidation resistance of columbium by alloying appears promising.

Studies of the effect of binary alloy additions of titanium, chromium and zirconium up to 35 at.%, vanadium, molybdenum, tantalum and tungsten to 25 at.%, and beryllium, boron, cobalt, iron, manganese, nickel and silicon to 5 at.% on the oxidation and contamination resistance of columbium were carried out. The latter effect is of considerable importance since columbium may be seriously embrittled by diffusion of oxygen from the oxide scale. Testing was done in air at 600, 800 and 1000° C. (1110, 1470 and 1830° F.). The extent of contamination was determined by means of hardness traverses on the oxidized specimens.

The results reveal that:

1. Additions of titanium, chromium, molybdenum and vanadium improve the oxidation resistance of columbium. This oxidation resistance improves with increasing amounts of titanium up to at least 25 at.% Ti. Optimum oxidation resistance occurs at 5 at.% Mo, 10 to 20 at.% Cr and 5 to 10 at.% V for these binary alloys. The oxidation resistance of columbium at 600 and 800° C. (1110 and 1470° F.) is improved by adding 35 at.% Zr. All of the alloys studied oxidized in a linear manner, similar to the oxidation of pure columbium at temperatures over 500° C. (930° F.).

2. Binary additions of up to 25 at. % W and Ta and up to 5 at.% B and Si do not significantly improve the oxidation resistance of columbium. Severe losses resulted during arc melting binary alloys of columbium with aluminum, beryllium, cobalt, iron, manganese and nickel, and conclusions could not be drawn from the data obtained.

3. Additions of titanium, zirconium, chromium and vanadium reduce internal contamination of columbium by oxygen significantly. The alloy containing 35 at.% zirconium showed exceptionally good results in this respect. The contamination resistance of the titanium alloys increased with increasing titanium content up to 35 at.%. At 1000° C. (1830° F.) the alloy with 20 at.% chromium possessed comparable contamination resistance to the best titanium alloys tested.

4. Additions of up to 25 at. % Mo,

(Continued on p. 236)

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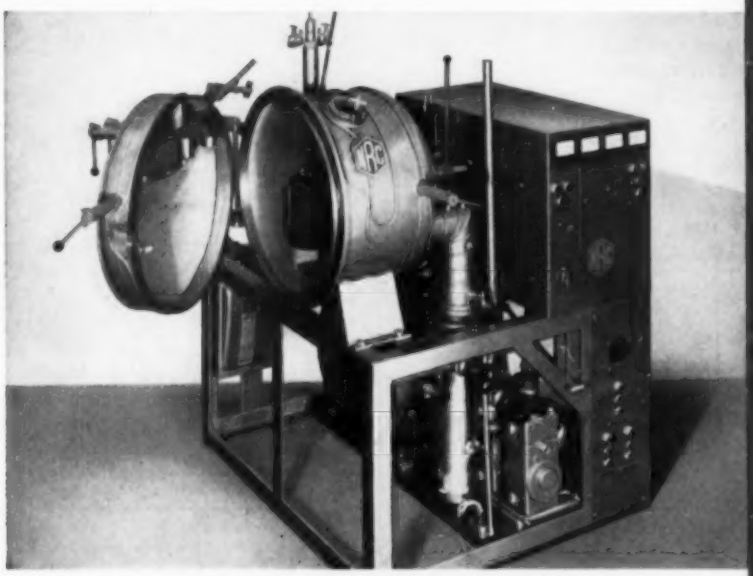

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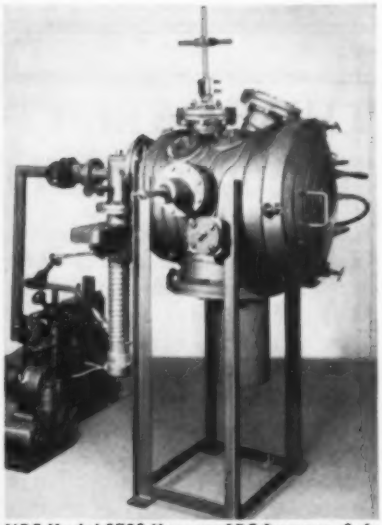

NRC Model 2703 Vacuum ARC Furnace. Safe and versatile unit for consumable or nonconsumable electrode melting into cold mold or skull (consumable head not shown). Other arc furnaces with capacities to 10,000 lbs.

NRC Model 2904-B Vacuum RESISTANCE Furnace. Over 100 now in use for melting, purifying, alloying, casting, sintering, brazing, annealing, and heat treating. Capacity 2-8 lbs. Temperature above 2000°C. Pressures to 10^{-5} mm Hg. Other standard resistance bell, muffle, and pit furnaces with hot zones to 54" dia. by 12'.

If you're considering vacuum metallurgy as part of your product improvement or quality control program, you don't have to start from scratch. You can get a head-start by drawing on the experience NRC has gained from building and operating more high vacuum furnaces than any other organization in the world. You can easily find out

If vacuum metallurgy can help you as it has others.
Whether you really need to run your own development program.
What type of furnace would be most suitable for your program.
How to avoid the expensive pitfalls which have so often trapped beginners.

Then, if you decide to run your own development program, you'll find you can get started easily, economically and quickly with a standard NRC furnace, such as those shown here. You won't need a vacuum expert to run it either. NRC furnaces are designed for simplicity, and our engineers will teach you up-to-date operating techniques. This is the way for you to get useful results sooner, with a minimum investment in equipment, time, and operating costs.

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BRISTOL'S INSTRUMENTATION

★ NEWS AND INFORMATION ABOUT AUTOMATIC CONTROLLING AND

THEY CALL IT "the instrument man's instrument"

That's because more and more instrument men—engineers, scientists and research workers—are turning to Bristol Electronic Dynamaster* potentiometer and bridge instruments to fill exacting requirements. These men *demand* the utmost in instrument accuracy, precision and dependability; they *need* an instrument that's outstandingly versatile and adaptable in application. They get these qualities and more in Bristol Dynamaster instruments. Take these Dynamaster features, for example:

1. Continuous standardization—accurately, automatically, and continuously standardizes potentiometer against standard cell with no interruption to control. Eliminates dry cells and usual standardizing mechanism.
2. High accuracy . . . fast, continuous electronic measurement.
3. Simple in design . . . few moving parts.
4. Easy to use and service . . . little or no maintenance required.
5. Flexible in application.
6. Rugged construction . . . ideal for industrial plants, pilot plants, and for research and laboratory use . . . unaffected by vibration.

Models for every purpose. Dynamaster electronic instruments are available as single-pen, two-pen, and multiple-record (up to 24 points) strip chart instruments. Round chart instruments are also available with one and two pens.

(And remember the 3-inch-strip-chart miniature Dynamaster described below.)

Electric and pneumatic controllers. Both strip- and round-chart instruments come with a wide variety of controllers. The following are available in a great many forms:

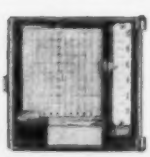
Electric Control—On-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—On-off, proportional, proportional with reset, and proportional with reset and derivative.

*T.M. Reg. U.S. Pat. Off.

Bristol Dynamaster* recorder with strip chart.

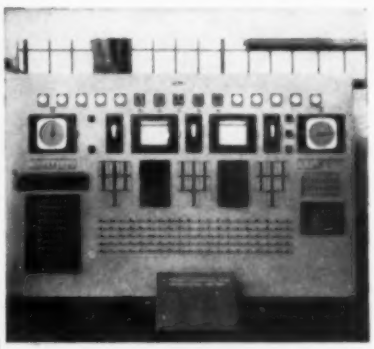
This new electric miniature takes on big jobs



New Bristol Series 663 miniature Dynamaster instruments plug into panel space of only 5"x5⅛". But they work on the same motor-driven self-balancing principle as full-sized Bristol Dynamaster instruments. This proved motor-driven null-balance principle not only gives high accuracy (½% of scale) but insures plenty of torque for operating alarm contacts, retransmitting slide-wires, and electric control contacts—features that ordinary galvanometer-type instruments don't have.

Plugs in, too. What's more, the Series 663 Dynamaster has a true plug-in chassis. You can change from an indicator to a recorder, or vice versa, in 10 seconds, or plug in spare instruments with minimum interruption to recording or control.

Ask us for complete data on Series 663 Dynamaster recorders and indicators today. As the only manufacturer making a complete line of *both* miniature and full-size instruments we're in unique position to give your instrument needs unbiased consideration.



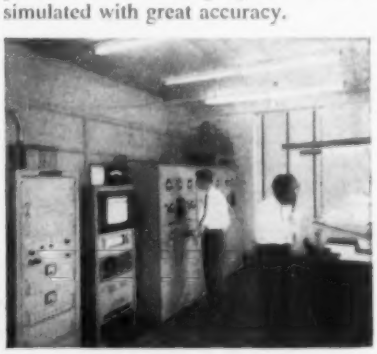
Keeping tabs on atoms

This automatic control and information center, designed and built by Panellit, Inc., for Knolls Atomic Power Laboratory features four Bristol Dynamaster instruments (in second row from top). Dynamaster recorders and controllers are finding wide application in atomic energy, as in other industries, where precision, accuracy and reliability are prime requirements.

Break "thermal barrier"

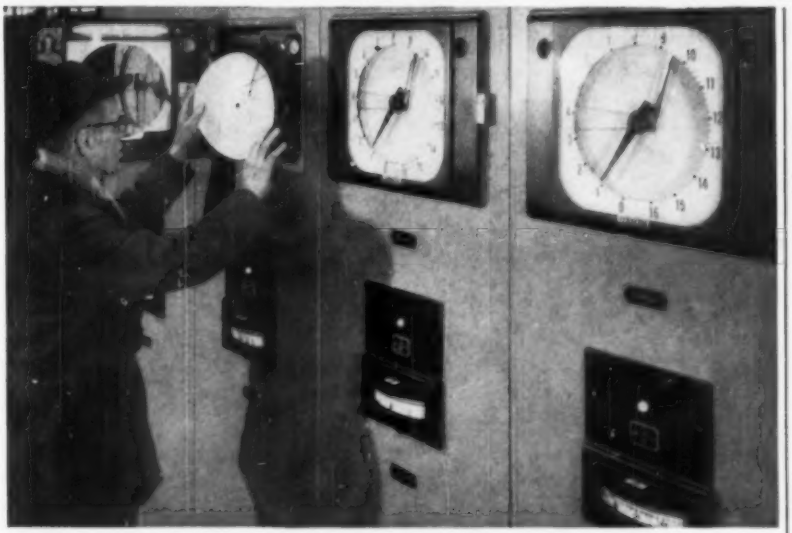
A Bristol Dynamaster high-speed temperature recorder transcribes test results in the Westinghouse Elevated Temperature Structures Test Facility shown here during its development.

The system is designed to test aircraft and missile structures under temperature conditions simulating flight through the air at speeds up to 5000 mph. The equipment can produce temperatures of 2650° F in 13 seconds. Desired temperature-versus-time programs can be simulated with great accuracy.



NEWS AND NOTES

RECORDING INSTRUMENTS FOR THE METAL-WORKING INDUSTRY ★



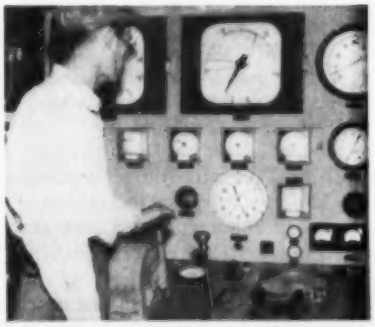
Instruments help turn out casting cores at 7 tons/hour

Engine blocks for Ford and Mercury automobiles are cast with strictest attention to accuracy and structural quality at the Cleveland foundry of the Ford Motor Company, Brookpark, Ohio, just outside Cleveland.

Yet these rigorous requirements must not impede the smooth flow of the production line. That's one reason Ford installed this battery of Bristol Dynamaster* instruments.

Another: In the early days, core baking used to be an all-night process. Cores were of fine quality, but the output was too low for present-day production lines. The new core baking method turns out top quality cores at the rate of 7 tons an hour. Bristol instruments automatically hold the baking temperature to 450° ± 5°F. And, in emergencies, allow faster processing by raising the temperatures and increasing conveyor speed.

First oxygen steel plant uses Bristol controls



Bristol round chart Dynamaster* Instruments (top) and Bristol Metagraphic miniatures (center row) play a big part in controlling oxygen steel-making at Dominion Foundries & Steel, Ltd.

When Dominion Foundries & Steel, Ltd. (Dofasco), at Hamilton, Ontario, first introduced this method of steel-making to the North American Continent, they chose Bristol instruments and controls (above) to supervise the most critical steps in the process.

These include oxygen pressure and flow (current rate and total), lance position, lance cooling water temperature, flow, and pressure as well as various other temperatures.

The big advantage of oxygen steel-making is the lower original investment in equipment. Only about 50% of the equipment costs of competitive processes is required and operating costs are no higher, with equal or better product.

Furnace, oven, dryer— Bristol controls them all

Whatever your industrial heating application, you can find a Bristol instrument or instrument system to provide precision indication, recording or automatic control. The following instruments, in almost innumerable variations, are typical of the truly complete Bristol instrument line.

Bristol's Dynamaster* Potentiometer Pyrometers come in round or strip chart models, provide electronic recording, indication, and electric or pneumatic control, including high-low contact, proportional, time-program and many combinations. The outstanding instrument for maximum precision.

Bristol Millivoltmeter Pyrometers. Both indicating and controlling models available. Controlling models utilize unique Bristol Free-Vane* principle that completely eliminates relay "chatter" or "flutter." High-low contact and proportional models available in a wide variety of combinations.

Bristol Miniature Instruments – Bristol is the only company offering a complete line of instruments in both miniature *and* full-size for all recording, indicating and control applications, both electronic and pneumatic. True plug-in construction. Ideal where panel space must be conserved.

*T. M. REG. U. S. PAT. OFF.

Write for complete data on Bristol instruments for your furnace, oven, dryer or kiln. And remember, Bristol makes a complete line of thermocouples and pyrometric accessories. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

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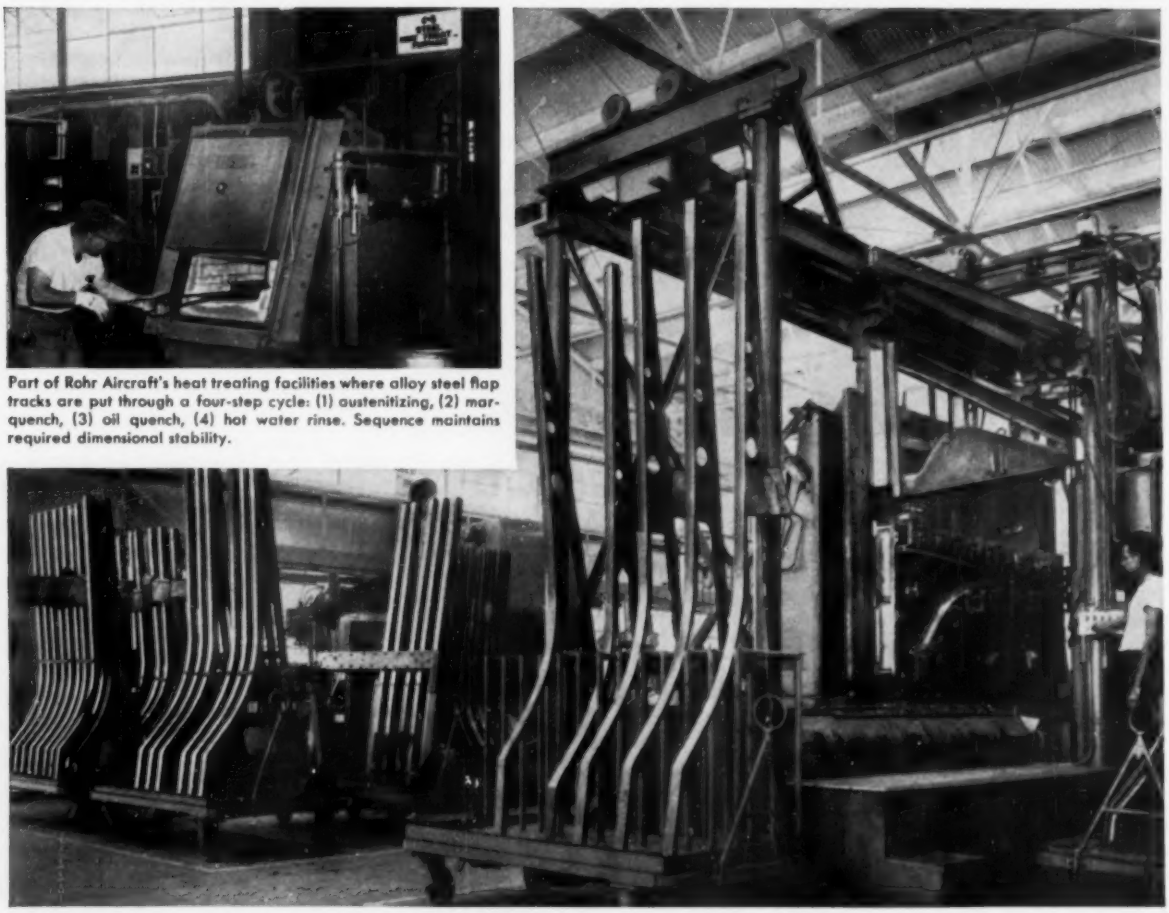
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Problem-Solving Products from Republic

Increase Strength/Weight Ratios, Cut Costs, Save Weight, Maintain Dimensional Stability

Part of Rohr Aircraft's heat treating facilities where alloy steel flap tracks are put through a four-step cycle: (1) austenitizing, (2) marquench, (3) oil quench, (4) hot water rinse. Sequence maintains required dimensional stability.



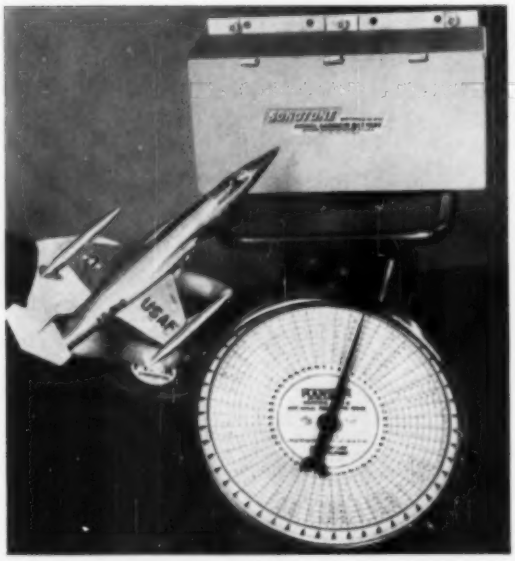
ALLOY STEEL MEETS HIGH STRENGTH, PRECISION REQUIREMENTS IN USAF BOMBERS. Steel weldments produced by Rohr Aircraft Corporation, Chula Vista, California, are an excellent example of the aircraft industry's constant effort to develop better and more economical methods of mass-producing large, high-strength structural aircraft components.

Rohr is currently using this weldment technique in manufacturing flap tracks for an Air Force bomber. The flap tracks are fabricated from AMS 6428 Alloy Steel, a type supplied by Republic. This fine steel provides a minimum tensile strength of 180,000 psi in the heat treated condition. Uniform response to heat treatment assures exceptionally good deep hardening characteristics—plus hard, wear-resistant surfaces.

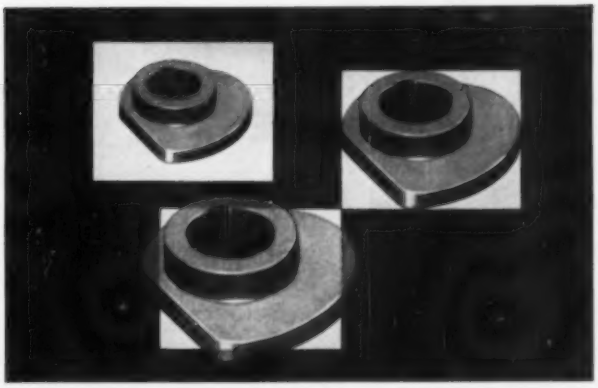
The exceptionally high strength-to-weight ratio of Republic Alloy Steel combined with the highest strength values permits the design of thinner, lighter track sections to save weight and hold down size without sacrifice of strength or safety.

Rohr's development of specialized tooling, welding, and heat treating techniques permits the production of these alloy steel weldments to close tolerances—a rigid aircraft engineering requirement. Costs are reduced by eliminating the need for expensive equipment and excess stock removal.

Specify Republic Alloy Steel for your parts that must be tough, strong, dependable. Our metallurgists are always available to help you in selection and processing. The coupon is your invitation to use this obligation-free service.



REPUBLIC STAINLESS STEEL. Type 302, cuts costs, saves weight, resists corrosion in jet aircraft storage battery cases made by Sonotone Corporation, Elmsford, New York. Stainless steel's exceptionally high strength-to-weight ratio and ability to withstand impact and vibration permits the use of a lighter gage, thus saving weight. Sonotone reports the metal's outstanding corrosion-resistance eliminates the need for painting the cases with no detrimental effect on service or appearance. Republic Stainless Steel also resists the wide extremes of temperature and atmosphere through which the batteries must operate. Mail the coupon for more facts on Republic ENDURO® Stainless Steel.



REPUBLIC IRON POWDERS with Controlled Dimensional Factor give your parts predictable dimensional characteristics after sintering. CDF means that in the presence of copper, Republic Iron Powder—depending on type—can be made to grow, shrink, or remain stable within acceptable tolerance limits. Tool engineers can design tools to part-print dimensions with the assurance that tolerances, transverse to the direction of pressing, can be held within ±.001 inches per inch. Fabricators can produce consistently uniform sinterings at faster rates and at minimum cost. Republic Booklet Adv-763 contains complete details. Send coupon for your copy.

REPUBLIC TITANIUM ALLOYS are used for weight saving and elevated temperature applications in the B-58 Hustler. The supersonic bomber is built for the Air Force by Convair, a division of General Dynamics Corporation, Fort Worth, Texas. These particular titanium alloys have minimum tensile strength of 130,000 psi and a minimum yield strength of 120,000 psi. Among the strongest alloys now being produced, they meet the demand for high strength to resist the effects of aerodynamic heating in supersonic aircraft, such as the B-58. Republic metallurgists and engineers, pioneers in the development of high strength-to-weight metals, are ready to help you apply titanium to your product or process.

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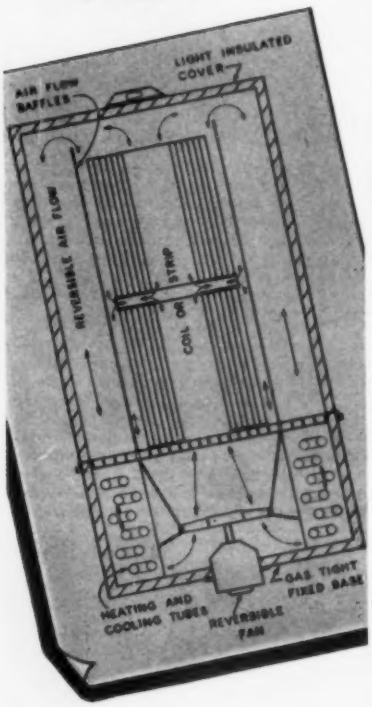

R-S Single Stack* Annealing... Faster Heating, Automatic Airflow Reversal... Uniform Heating

Designed for faster heating and cooling with forced convection and automatic airflow reversal—allows absolute uniformity of heating with no spotty sections on coils.

Lightweight, insulated, one-piece cover. Permanent fuel-air connections. Annealing of copper, brass and bronze strip and wire accomplished in only ⅓ of time required for conventional annealing. Only one seal to maintain with one cover to handle. Factory assembled unit with true portability.

Write for details on strip and wire annealing.

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*Patent Pending

R-S FURNACES

Columbium . . .

Ta and W, and up to 5 at.% Si, resulted in negligible improvement in contamination resistance.

Following the weight-gain measurements, X-ray diffraction studies were conducted on the oxide scales removed from the most promising oxidation resistant alloys tested at 1000° C. (1830° F.). The data indicate that most of the alloys formed either the M-type or H-type (stable above 1100° C.) Cb_2O_5. The low-titanium alloys, all of the vanadium alloys, and the 10 at.% chromium alloys have oxides with new crystal structures similar to M and H-type Cb_2O_5, but with greater symmetry This infers that a mixed oxide may be occurring in the majority of the less oxidation resistant alloys. The most promising alloys, 15 at.% Cr, 5 at.% Mo, 25 at.% Ti, and 10 at.% V all show M and H-type Cb_2O_5, with the exception of the latter. The improvement in the oxidation resistance of columbium is apparently consistent with the presence of an alloying element which will substitute for columbium in the outer scale, which retains the Cb_2O_5 structure.

R. T. Begley

Yielding of Mild Steel

Digest of "Effect of Grain Size and Carbon Content on the Yield Delay-Time of Mild Steel", by J. M. Krafft and A. M. Sullivan, ✪ Preprint No. 65, 1958.

Experimental and theoretical investigations are rapidly increasing our knowledge of the unusual mechanical behavior of iron and mild steel. Rapid loading to a constant stress level is an informative though not widely used method of experimentally studying the yielding of mild steel. The present work is an attempt to relate the behavior of steel under rapid loading to structural features of the steel, particularly ferrite grain size and carbon content.

A modified Hopkinson bar apparatus is used to load small cylindrical steel specimens in compression. Oscillograph recording of the stress shows that a chosen constant stress is reached in about 5 microsec. and is held constant for 570 microsec. At appropriate stress levels, yielding

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A non-ferrous alkaline compound for use in tumbling barrels, Ahco Deruster No. 11-E produces a clean bright surface.

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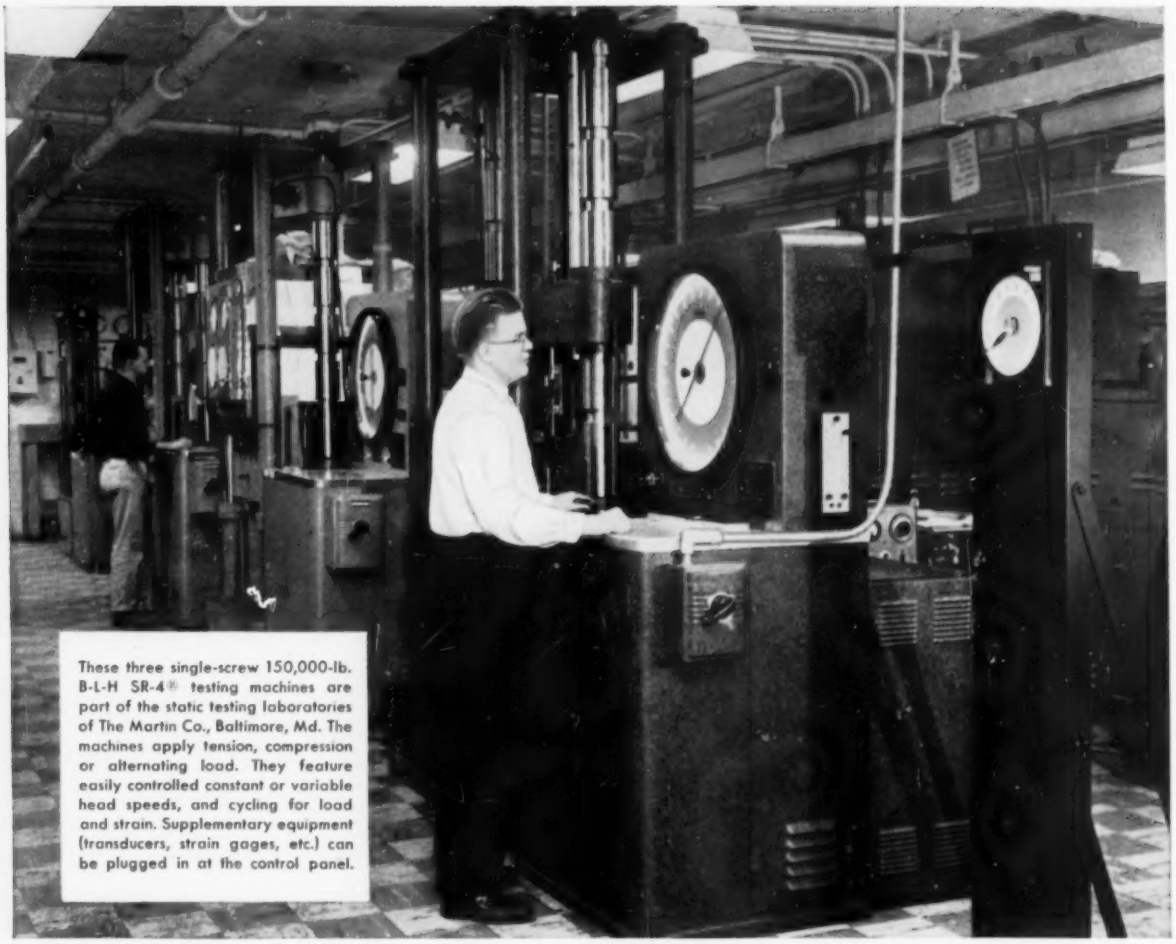

These three single-screw 150,000-lb. B-L-H SR-4® testing machines are part of the static testing laboratories of The Martin Co., Baltimore, Md. The machines apply tension, compression or alternating load. They feature easily controlled constant or variable head speeds, and cycling for load and strain. Supplementary equipment (transducers, strain gages, etc.) can be plugged in at the control panel.

Martin labs use B-L-H equipment in 6-year program of fatigue, static, creep tests

As part of the preplanning on an enormous testing program to support design work on aircraft and missiles, The Martin Co., of Baltimore, Md., outlined its extensive requirements to B-L-H. Because exhaustive testing is a vital part of the aircraft industry, the equipment used must be versatile, accurate and durable. Tests are both static and dynamic and include tension, compression, flexure, creep and fatigue.

Equipped with 28 B-L-H testing machines in the static and fatigue laboratories of its Baltimore plant alone, The Martin Co. has just completed a massive 6-year testing program successfully. Its B-L-H fatigue machines have operated constantly, day and night, 7 days per week for 6 years, requiring no maintenance except lubrication. With B-L-H creep testers in conjunction with a photographic measuring process originated at Martin, creep deformation is read to a sensitivity of .00001 in. And the SR-4 testing machines (shown above) duplicate on test components the entire strain history of an aircraft. They can also hold constant loads and they have eliminated the need for three shifts of operators working for 3 days to supervise 72-hour tests.

Whatever your testing requirement . . . compression, tension, creep, fatigue, impact or torsion . . . see B-L-H first. Or write 2-J and ask to have a B-L-H man call on you.

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Electronics & Instrumentation Division

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You can be sure, when you specify or order from Revere, that you will get not only fine metal but fine service, including Revere's cost-saving Technical Advisory Service if desired. Revere—now an integrated producer of aluminum—can supply you from large modern sheet mills in Baltimore, Md., and Chicago, Ill.

In addition to aluminum coiled and flat sheet, circles and blanks, both plain and embossed, Revere can furnish aluminum seamless drawn, welded and extruded tube; extruded shapes; forgings; foil; and primary aluminum pig and ingot.

It pays to do business with the most dependable sources of supply—such as Revere, which has been fabricating fine non-ferrous metals for more than 150 years.

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What
How
How

They Are
They Get There
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Prof. R. Weck of Cambridge University and Director of the British Welding Research Association, will be brought to America this October to deliver seven important lectures on residual stresses. Coupled with these outstanding lectures will be seven discussion periods by 14 American experts.

This Seminar will be held during the latter part of Metal Show Week

October 30, 31 and November 1, 1958

Registration Fee: **Including outline notebook, complete transcript of proceedings, lunches and dinners for three days, $150.00. (Early registration with $25 deposit suggested.)**

Place: **Wade Park Manor, Cleveland**

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Yielding of Steel . . .

takes place after a certain time interval called the delay-time. As yielding occurs, the stress supported by the specimen drops sharply to a lower value, called the flow stress, which corresponds to the lower yield stress at the strain rate inherent in this type of test (which is very large). The materials investigated included killed steels of 0.01, 0.11, 0.22 and 0.33% C, two ship steels (one semikilled and the other killed), and a quantity of the 0.17% carbon steel used previously by Clark and Wood in their investigations of the behavior of steel under dynamic loading. A series of tests on this steel has confirmed and extended the results of Clark and Wood, and at the same time has shown the validity of the present testing procedure.

The microstructures of the ship steels were varied by systematic heat treatments. The parameters used to describe the structures obtained were the ferrite grain size, the ferrite path between patches of pearlite, and the pearlite patch size. For a constant yield delay-time, the stress required to cause yielding was lower for the coarser-grained steels. This result is consistent with the general tendency of slow speed yield strength values to decrease with increasing grain size. The flow stress values at a given strain rate correlated well with either the ferrite grain size or the ferrite path between pearlite patches, in accord with several investigations of the effect of grain size on the lower yield stress. However, in the instance of the stress supported prior to yielding, which is associated with the upper yield stress, a significantly better correlation exists with pearlite patch size than with the other microstructural parameters. Increased supported stress accompanies decreased pearlite patch size. Such a correlation would be difficult to prove or disprove in ordinary testing because other factors, particularly stress concentrations, affect the value of the upper yield stress.

The behavior of the steels from 0.01 to 0.33% C was investigated at temperature intervals in the range −69 to 123° C. (−92 to 254° F.). The steels have Charpy transition temperatures in this range, and the

When this door comes down . . . so does your blast cleaning cost!

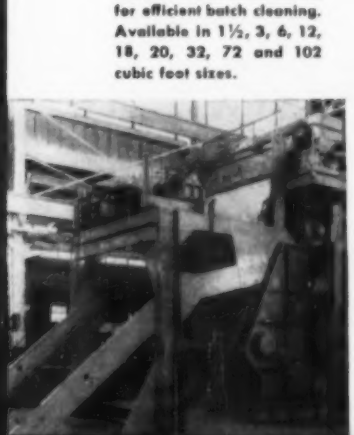
Abrasive-tight door on Rotoblast Barrel slashes "lost abrasive" costs

Look at it. That door on the Pangborn Rotoblast Barrel is engineered to prevent waste. Heavy steel plates . . . an exclusive arrangement that permits raising the door for easy maintenance . . . *clamp*-closing to make it really abrasive-tight! As a result, here is another way that Pangborn Rotoblast Barrels save you money.

This door is just one of the many benefits built into Rotoblast Barrels. Efficient Rotoblast operation, for example. Automatic control. Ease of maintenance. Plus specific construction features that all add up to *better* cleaning in *less* time for *lowest* cost per ton.

The Pangborn Engineer in your area will be glad to take off his coat and go to work on your cleaning problem at no obligation. And for complete information on Rotoblast Barrels, write to: Pangborn Corp., *1800 Pangborn Blvd., Hagerstown, Md. Manufacturers of Blast Cleaning & Dust Control Equipment.*

Pangborn Rotoblast Barrel for efficient batch cleaning. Available in 1½, 3, 6, 12, 18, 20, 32, 72 and 102 cubic foot sizes.



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Rolock experts in welded alloy fabrication are ready to go anywhere at any time to aid in designing equipment to meet special service requirements. Rolock service is based on a well-rounded coordination of experienced design and supervisory engineering, extensive modern manufacturing facilities, inspection and test equipment.

Alternatively, send us an outline of your requirements for our recommendations or for quotations to your specifications.

Special INCONEL High Temperature Vacuum Retort approximately 2 ft. in diameter by 8 ft. high.

VACUUM RETORTS

We have the facilities and experienced personnel to handle your requirements in special vacuum retorts welded-fabricated from Nickel, Inconel, or other special alloys. Rolock assures experienced engineering supervision and production in a modern plant fully equipped for inspection and testing as well as fabrication.

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Illustration shows one of many special large fabrications typical of this type of equipment made by Rolock. This bell is of ⅜" Inconel and, together with its base, incorporates a number of unusual features. Rolock is equipped to build and test such equipment to customer's exact specifications.

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Yielding of Steel . . .

connection between rapid loading and tendency to brittle failure prompted the study of the steels over this range. Both the supported stress values and the flow stress values increased with increasing carbon content and with decreasing testing temperature. (The behavior of the lowest carbon steel is quite similar to that of one of the ship steels in this test, even though these steels exhibit marked differences in transition temperature.) A smooth curve of supported stress versus temperature is best obtained when the supported stress values are adjusted to constant pearlite patch size. The shape of the curve so obtained is similar to a published curve of the lower yield stress as a function of carbon content.

The use of a rapid loading technique of testing has enabled the authors to show the importance of microstructural parameters, particularly the amount of pearlite present and its distribution, in the yielding behavior of a range of mild stels.

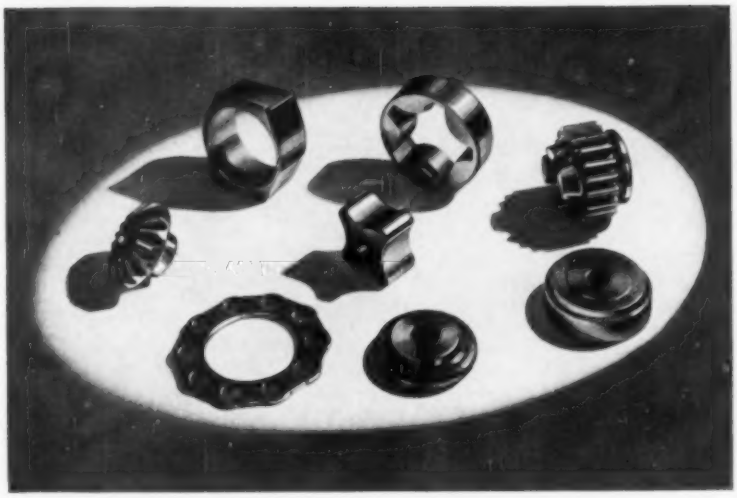
D. A. THOMAS

Rate Process Theory for Heat Treatment of Titanium

Digest of "The Application of Rate Process Theory to the Heat Treatment of Titanium Alloys", by N. M. Erkun, ⊕ Preprint No. 90, 1958.

THE DEVELOPMENT and use of heat treated titanium alloys in critical applications requires extensive knowledge of the properties resulting from various heat treatments. A method of plotting heat treating data to permit the more effective estimation of the aging conditions and obtain desired mechanical properties was developed, and, incidentally, the number of tests needed to evaluate heat treated properties was reduced. Only properties resulting from overaging were considered.

Aging curves were established by plotting mechanical properties against time of aging. The overaged portions of these curves were selected, and, since overaging is presumably diffusion-dependent, it was possible to apply the familiar rate



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Rate Process Theory . . .

process equation to the plotting and prediction of the relationships between mechanical properties and aging times and temperatures, at a constant solution treatment.

The rate equation is:

$$\text{Rate} = Ae^{-\frac{Q}{RT}}$$

Where A is a constant, Q is the activation energy for the process, R is the gas constant, and T the absolute temperature. This can be reduced to:

$$C = \frac{Q}{2.3\,RT} - \log t$$

(for a constant property)

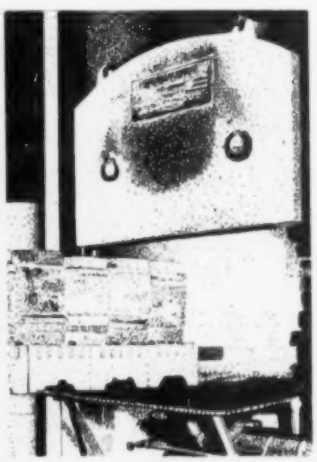
and $T(C + \log t) = \frac{Q}{2.3\,R}$

where C = log A, and t is the time. By plotting log t versus $\frac{1}{T}$ for a constant property, the slope equals $\frac{Q}{2.3\,R}$, and both Q and C can be calculated.

Four C 120 AV (90 Ti, 6 Al, 4 V) and three C 135 AMo (89 Ti, 7 Al, 4 Mo) heats were used in the investigation. All specimen blanks were annealed, solution treated (C 120 AV at 1700° F., C 135 AMo at 1750° F.), then aged over a range of times and temperatures. The mechanical properties were determined, the data plotted, and values of Q and C for both alloys at different strength levels determined. Typical values were:

Alloy	U.T.S. Psi.	Q. Kcal./G-Mol.	C
C 120 AV	150,000	69	15.5
C 120 AV	155,000	61	14.1
C 135 AMo	185,000	92	21.3
C 135 AMo	190,000	79	18.5

For convenience in establishing the aging parameter, T (C + log t), plots, C was taken to be 15 for C 120 AV and 20 for C 135 AMo alloy. Using these values and the aging data obtained experimentally, plots were constructed relating ultimate tensile strength, 0.2% offset yield strength, per cent elongation, per cent reduction of area, Rockwell C hardness, and −40° F. Charpy impact values to the aging parameters of each alloy at constant solution temperature, time and bar size, for each heat considered. Scatter bands were drawn on each plot. The applicability of the data is limited to fine equiaxed, alpha-plus-beta (peppery) microstructures resulting from alpha-beta rolling or forging of these alloys.



These aging parameter plots give minimum, maximum and range of heat treated properties resulting from any overaging treatment, and permit the selection of an aging treatment to obtain a given level of mechanical properties, as well as the selection of alternate equivalent aging treatments, involving different aging temperatures or times, to produce similar mechanical property combinations.

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Brittle Fracture of Titanium Alloys

Digest of "The Effect of Composition on the Hydrogen Embrittlement of Alpha-Beta Titanium Alloys", by R. I. Jaffee and D. N. Williams, Preprint No. 98, 1958.

THE EFFECT of hydrogen in promoting brittle fracture in alpha-beta titanium alloys is a function of alloy content, ratio of amount of alpha to beta phases, the distribution of the beta phase, and the rate of straining. Hydrogen dissolved in beta is the source of hydrogen for slow-strain embrittlement because most of the hydrogen partitions to beta; room-temperature alpha solubility for hydrogen is very low. There is a good correlation between the appearance of a third phase taken to be a hydride and the hydrogen tolerance for slow-strain embrittlement. Alloys in which a hydride phase is present at low hydrogen contents generally have low hydrogen tolerance in impact loading. Slow-strain embrittlement is generally somewhat less than the amount corresponding to the appearance of hydride in the microstructure, whereas impact embrittlement is generally accompanied by the appearance of the hydride phase. This suggests that slow-strain embrittlement results from hydride precipitation during straining.

The hydrogen tolerance increases with beta-stabilizing alloying content which results in increasing amount of beta phase. Molybdenum-containing beta is the most resistant to hydrogen embrittlement. Columbium and chromium-containing betas are moderately resistant whereas vanadium, iron, and manganese-containing betas exhibit very little resistance to embrittlement. The presence of 4% or more aluminum, an alpha stabilizer, in addition to a beta-stabilizing element in titanium, increases the over-all hydrogen solubility and hence the tolerance for hydrogen against slow-strain embrittlement of such alloys. Oxygen decreases hydrogen tolerance of alpha-beta titanium alloys. The most detrimental microstructure for slow-strain embrittlement is one containing long continuous interfaces between alpha and beta phases.

The alpha-beta alloys susceptible to hydrogen embrittlement may be classified into the following distinct categories:

1. Alloys with high solubility for hydrogen in the beta phase. These alloys generally contain a significant percentage of molybdenum, the element with the greatest beneficial effect on hydrogen solubility in beta.

2. Alloys with high tolerances for hydrogen because of high solubility for hydrogen in the alpha phase. These are alloys containing 4% or more aluminum. Their over-all tolerance for hydrogen depends on the nature of the beta-stabilizing element used in conjunction with aluminum. Tin is much less effective than aluminum in increasing the hydrogen tolerance.

3. Alloys with low solubility for hydrogen which are not susceptible to slow-strain embrittlement but which are notch-impact embrittled. These are illustrated by alloys such as Ti-Ta and Ti-2 Fe, where the beta phase is globular with no long continuous alpha-beta interfaces.

4. Alloys with relatively low solubility for hydrogen in both alpha and beta, such as Ti-Mn, which are susceptible to slow-strain embrittlement at lower hydrogen contents before the appearance of hydride.

T. E. LEONTIS

Hydrogen Tolerance of Titanium Alloys

Digest of "The Effects of Microstructure and Heat Treatment on the Hydrogen Embrittlement of Alpha-Beta Titanium Alloys", by D. N. Williams, F. R. Schwartzberg and R. I. Jaffee, Preprint No. 113, 1958.

A 20-lb. ingot was cast of each of four alpha-beta titanium alloys, 92 Ti, 8 Mn; 94 Ti, 2 Mo, 2 Fe, 2 Cr; 90 Ti, 6 Al, 4 V; and 92 Ti, 4 Al, 4 Mn. Through a series of processing steps, ¼-in. rounds were fabricated containing hydrogen at levels ranging from 20 to 800 ppm. The hydrogen content was adjusted by hydrogenation or vacuum annealing. Various heat treatments were employed to vary the alpha grain size and shape, and the amount of hydrogen required to induce low strain rate embrittlement was determined by subjecting the samples to several different physical tests: impact, fast tensile (0.5 in. per min.), unnotched

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4520	0.18/0.23	0.45/0.65	0.040	0.040	0.20/0.35	—	—	0.45/0.60	4520
4718	0.16/0.21	0.70/0.90	0.040	0.040	0.20/0.35	0.90/1.20	0.35/0.55	0.30/0.40	4718
8822	0.20/0.25	0.75/1.00	0.040	0.040	0.20/0.35	0.40/0.70	0.40/0.60	0.30/0.40	8822

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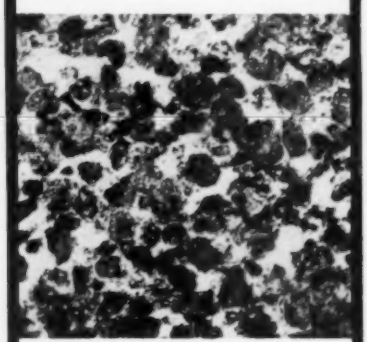

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Titanium alloys . . .

stress-rupture and notched stress-rupture tests. Except for one series of impact tests performed at —40° F., all testing was done at room temperature.

The amount of hydrogen which could be tolerated without causing embrittlement decreased as the heat treatment temperature was lowered, as the alpha grain size increased and as the grain shape became more acicular; the effect of heat treating temperature was the most pronounced. The hydrogen tolerance seemed to be independent of the strength of the alloy, except insofar as strength is varied by different final treatment temperatures – the lower temperatures developing the higher strengths but at the same time causing lower hydrogen tolerance.

A metallographic study was made to detect strain-induced hydride. The hydride phase was detected in the fracture region of aluminum-free alloys at hydrogen contents about 100 ppm. higher than the hydrogen content necessary to induce low strain rate embrittlement. In the case of the 94 Ti, 2 Mo, 2 Fe, 2 Cr alloy the hydride phase was detected at a hydrogen level as low as 100 ppm. The aluminum-containing alloys rarely were embrittled or showed strain-induced hydride at hydrogen contents less than 800 ppm.

The hydrogen tolerance of the four alloys examined decreased in the order 90 Ti, 6 Al, 4 V; 92 Ti, 4 Al, 4 Mn; 92 Ti, 8 Mn; and 94 Ti, 2 Mo, 2 Fe, 2 Cr.

Because a low final heat treating temperature results in a low hydrogen tolerance, the authors offer these words of caution: "It would appear that the hydrogen tolerance of alloys to be used when prolonged exposure to elevated temperature is likely should be examined after exposure to the service temperature, since the tolerance after exposure at 600 to 800° F. may be appreciably lower than that observed in the alloy after stabilizing at 1100° F., or even after aging at 900° F."

W. B. Opie

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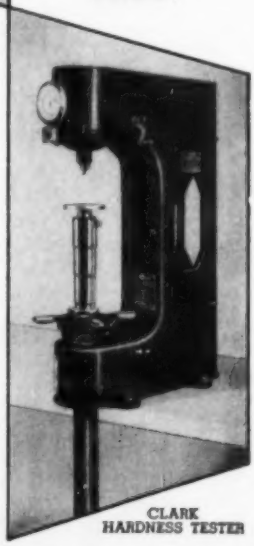

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Heat Treatment of Ti for Stress Stability at High Temperature

Digest of "The Effect of Heat Treatment on the Elevated-Temperature Stress-Stability of Titanium Alloys", by M. L. Greenlee, G. A. Lenning, W. M. Parris and H. D. Kessler, Preprint No. 94, 1958.

THE EFFECT of heat treatment on the elevated-temperature stress stability of three titanium alloys is reported. The alloys considered are Ti-140 A (2 Fe, 2 Cr, 2 Mo), Ti-155 A (5 Al, 1.5 Fe, 1.5 Cr, 1.5 Mo) and Ti-6 Al-4 V. Two solution temperatures and nine aging conditions resulted in 18 different heat treatments for each alloy. The various temperature-time combinations studied are shown below:

Alloy	Solution Temp. °F.
Ti-140 A	1400 to 1480
Ti-155 A	1600 to 1700
Ti-6 Al-4 V	1550 to 1750

All alloys were aged at 900, 1000 and 1100° F. for periods of 2, 8 and 24 hr.

Mechanical properties determined were: tensile properties from room temperature to 1000° F.; impact resistance (Charpy V-notch) from room temperature to 700° F.; notch tensile tests at room temperature; and stress stability tests. The stress stability tests consisted of exposure in a creep test at 550, 650, 750 and 850° F. for 500 hr. at stresses chosen to produce plastic deformation which varied from 0.1 to 2% in the 500-hr. tests. Six conditions of heat treatment were evaluated for stress stability. After the creep test, the specimens were tensile tested at room temperature to study changes that occur due to overaging, beta embrittlement by omega phase formation, or surface embrittlement.

Heat treating the Ti-140 A and the Ti-155 A alloy resulted in a marked improvement in high-temperature tensile properties. The Ti-6 Al-4 V alloy did not exhibit as dramatic a response to heat treatment although strength increases (25,000 psi.) were obtained with a 1750° F. solution temperature.

All three alloys maintained impact resistance above 10 ft-lb. at room temperature up to an ultimate tensile strength level of 180,000 to 190,000 psi. At room temperature, the ratio of notched to unnotched ultimate tensile strength dropped gradually from an average of about 1.55 for the three alloys in the annealed condition to 1.0 at an ultimate tensile strength level of 200,000 psi. This compares favorably with steels on a strength-weight basis. It is impossible to make a generalized statement regarding the effect of heat treatment on stress stability, since the variables of solution temperature and time, aging temperature and time, testing or service temperature and time, and stress level all can affect the stability of the structure. However, the general trends evident from this paper show that stability decreases as the aging temperature and time are decreased. It usually follows, therefore, that stability is decreased as the heat treated strength level is increased. The Ti-6 Al-4 V alloy was stable (showed negligible decrease in ductility or strength) under all conditions tested. The Ti-155 A alloy evidenced instability after several conditions of heat treatment. Varying the solution-treating temperature had no effect on the stability of Ti-6 Al-4 V or Ti-155 A alloys. The Ti-

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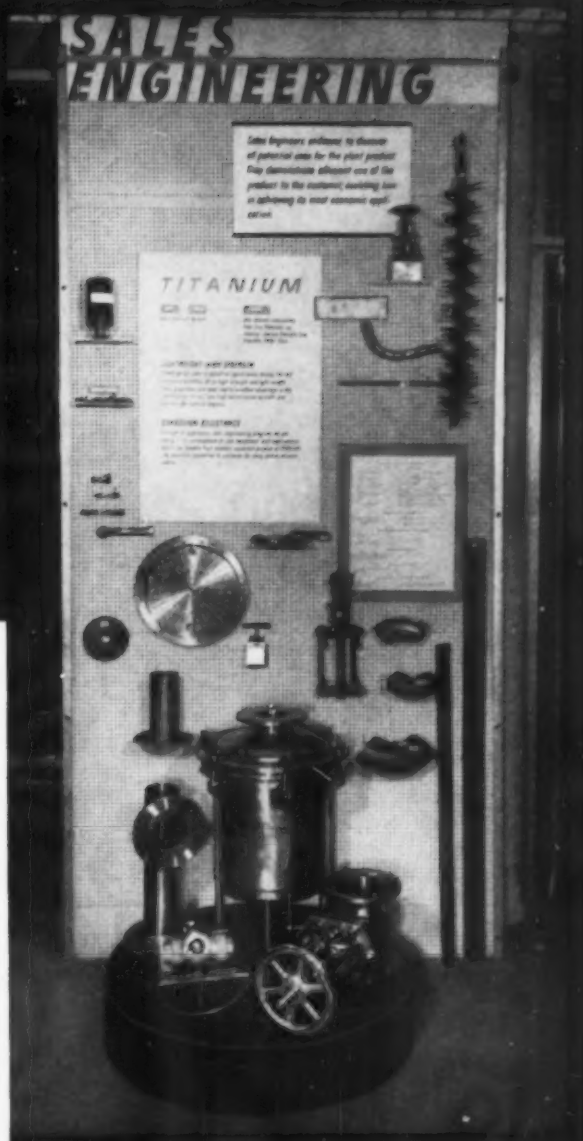

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Heat Treatment . . .

140 A alloy showed decreased stress stability after the higher (1480° F.) solution-treating temperature when aged at 900 or 1000° F. Solution treating at 1400° F. resulted in slightly lower strength but superior stress stability.

The creep resistance of all three alloys was improved by heat treatment since there was lower plastic deformation in the heat treated alloys during stress stability testing.

T. K. REDDEN

Notched-Bar Test

Digest of "Prediction of Transition Temperature in a Notched-Bar Impact Test", by J. A. Hendrickson, D. S. Wood and D. S. Clark, ASM Preprint No. 96, 1958.

NOTCHED-BAR IMPACT TESTS have been employed extensively for comparing the susceptibility of ferritic steels to brittle fracture. Above a certain transition temperature range, a steel behaves in a ductile manner; below this range, it will behave in a brittle manner. Although the range is typically 100 to 200° F., it is convenient to define a transition temperature for a given steel. This temperature lies within the transition range and is defined as the temperature at which a specified value of energy absorption is required in the impact test.

The information obtained from standard Izod notched-bar impact tests has been of great value for comparing the brittle fracture tendencies of certain steels. However, such tests have not provided quantitative information for use in engineering design calculation.

The purpose of the present investigation is to predict the transition temperature in the Izod test.

The value of the maximum tensile stress increases progressively as the applied load increases until a condition of instability of the plastically deformed region of the specimen is reached. Thus, brittle fracture occurs only if the critical stress for fracture initiation is reached prior to the onset of the plastic instability.

The true maximum tensile stress within a notched specimen at the instant of incipient plastic instability is proportional to the yield stress of the material. The strong influence of temperature upon fracture results from the marked variation of the upper yield stress with changes in temperature. The upper yield stress is also influenced, to a smaller degree, by the rate of stress application. Thus an increase in the rate of stress application tends to produce brittle fracture.

To make an analytical prediction of the transition temperature, the critical local tensile stress for the initiation of fracture must be known. The upper yield stress of the material, as a function of temperature for that rate of stress application which pertains to the notched-bar test, must also be known.

Using relaxation methods, the stress distribution inside the sample was computed. This led to the result that the maximum tensile stress inside the sample at the instant of incipient plastic instability was 2.41 times the upper yield stress. The rate of stress application at the notch was then calculated and was 9×10^9 psi. per sec. Experimental work available gave the change in the upper yield stress with stress rate from about 10^2 to 10^7 psi. per sec. and temperatures of -200, -110 and $+75$° F. The results were extrapolated to stress rates of 10^{10} psi. per sec., and the upper yield stress for a stress rate of 9×10^9 psi. per sec. was obtained for each temperature.

The ductile-brittle transition occurs when the maximum tensile stress is 210,000 ±10,000 psi., thus, at a value of the upper yield stress of 87,000 ± 4,000 psi. For the conditions involved, this stress corresponds to a temperature of 38° F., and this should be the transition temperature.

Suitable steel specimens were impact tested in a standard Izod impact testing machine, and the ductile-brittle transition occurred in a range of from 13 to 57° F., which is in surprisingly good agreement with the predicted temperature.

In addition, the elastic-plastic boundary was determined by hardness tests in specimens fractured at 25 and 50° F. Fracture occurred at 25° F. before deformation had spread across the section, whereas at 50° F. plastic deformation had spread completely across the specimen cross section at the notch.

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Negative Creep in Alloys

Digest of "The Phenomenon of 'Negative Creep' in Alloys", by R. W. Fountain and M. Korchynsky, ⊕ Preprint No. 91, 1958.

THE CREEP BEHAVIOR of engineering alloys is commonly influenced by metallurgical changes which occur in service. These structural changes are responsible for deviations from the creep behavior of a metallurgically stable alloy, and make extrapolations from the results of short-time creep tests to longer times inexact and impractical. The authors of this paper discuss a special instance of structural instability, namely, the contraction caused by a solid-state reaction which in service at elevated temperatures may outweigh the elongation due to the applied stress and caused a resultant "negative creep". Under imposed constant strain conditions, such contraction may lead to an increase in the initially applied stress. The authors present experimental results illustrating "negative creep" in iron-tungsten and nickel-molybdenum alloys, and show that the amount of contraction can be calculated from the known phase relationships and crystallographic data.

Measured creep elongation is the sum of true plastic deformation and length change resulting from structural instability. The rate at which structural changes occur may be influenced by the rate of deformation, and these changes will modify the work hardening and recovery processes.

So-called "negative creep" is only a special case of the more general behavior of alloys and is usually observed at relatively low temperatures and stress levels where the effect is neither exhausted quickly by very rapid precipitation nor overshadowed by large plastic strains.

At elevated temperatures, metallic materials may undergo solid-state reactions which are accompanied by appreciable density changes. Such density changes may result from allotropic transformations. Aging processes may also account for positive or negative volume changes. Similar behavior may be encountered when a metastable phase dissociates. Even in solid-solution alloys, volume changes may occur because of clustering, short or long-range ordering, or a preferential redistribution of solute atoms to the energetically more favorable positions, such as low or high-angle boundaries, dislocations, or stacking faults.

W. P. Sykes reports that solution-treated iron-tungsten alloys of 20 and 30% W, when aged for 1 hr. at 700° C. (1290° F.), show 0.32 and 0.4% contraction, respectively, and an iron alloy containing 22% Mo contracts 0.45% when aged at 650° C. (1200° F.) for 5 hr. These effects are attributed to the precipitation of the compounds of Fe_2W and Fe_7Mo_6, respectively.

The combined elongation effect of plastic deformation and solid-state reaction is shown for a negative volume change. The measured creep curve is the algebraic sum of curve C, representing normal creep of a stable metal, and curve D, representing contraction due to a metallurgical reaction. If for a given set of conditions, the contraction is large as compared to the normal creep elongation, "negative creep" will result. If the elongation is large (high stress) compared to the contraction, the conventional elonga-

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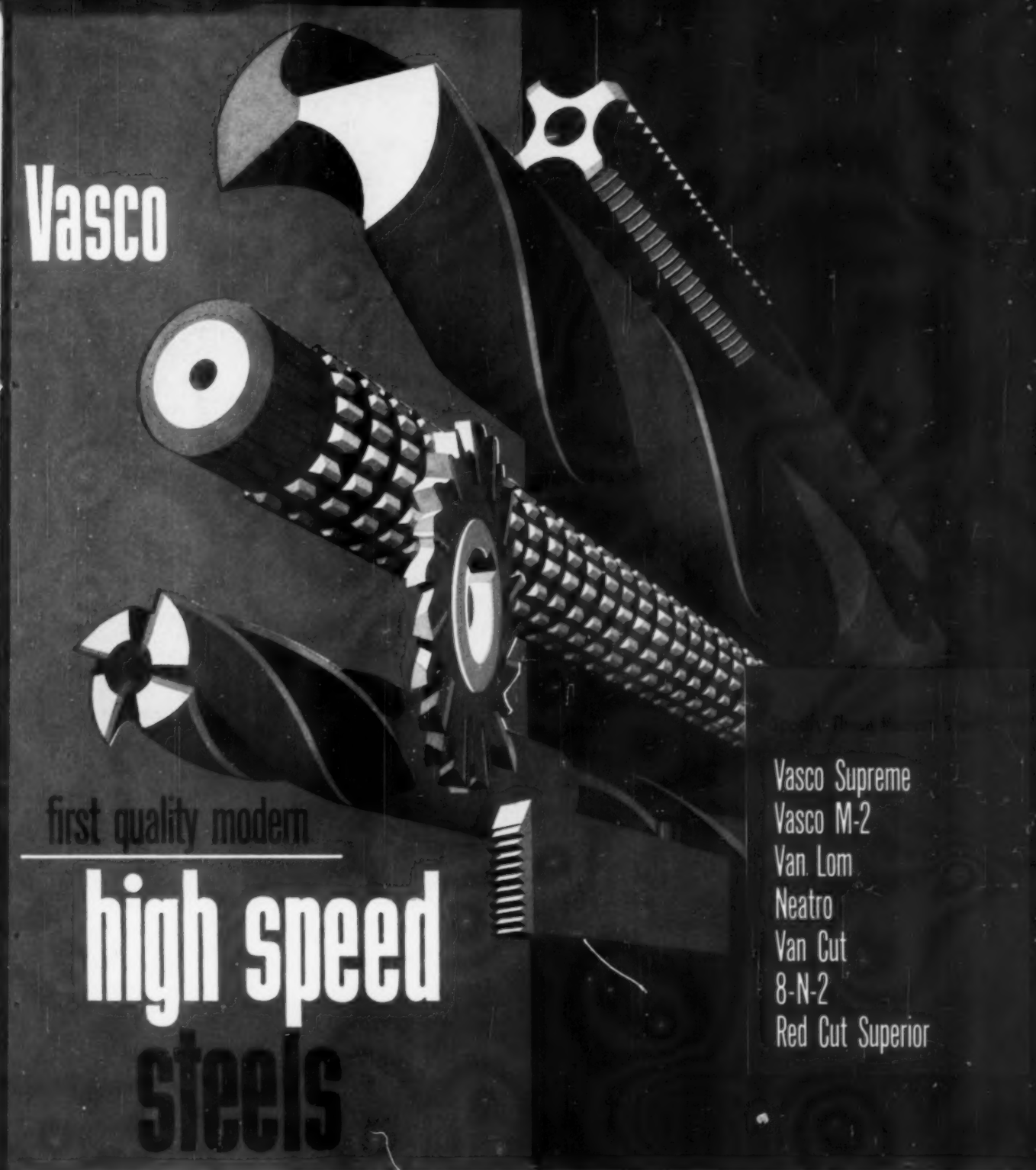

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Negative Creep . . .

tion time behavior will occur. If the elongation is small compared to the contraction in the early stages but becomes greater with time, the net creep curve will start negatively and gradually become positive.

For this study a 20.5% tungsten-iron alloy and a 25.5% molybdenum-nickel alloy were selected for investigation. The alloys were vacuum melted in an induction furnace, deoxidized with carbon, and cast as 2-in. square ingots. The ingots were subsequently forged and rolled to ⅝-in. diameter bars. The iron-tungsten alloy was solution treated at 1375° C. (2510° F.) and the nickel-molybdenum alloy at 1250° C. (2280° F.) and water quenched. Dilation measurements, creep tests, and stress-relaxation tests were made on the solution-treated materials and were supplemented by tests on cold worked or pre-aged alloy.

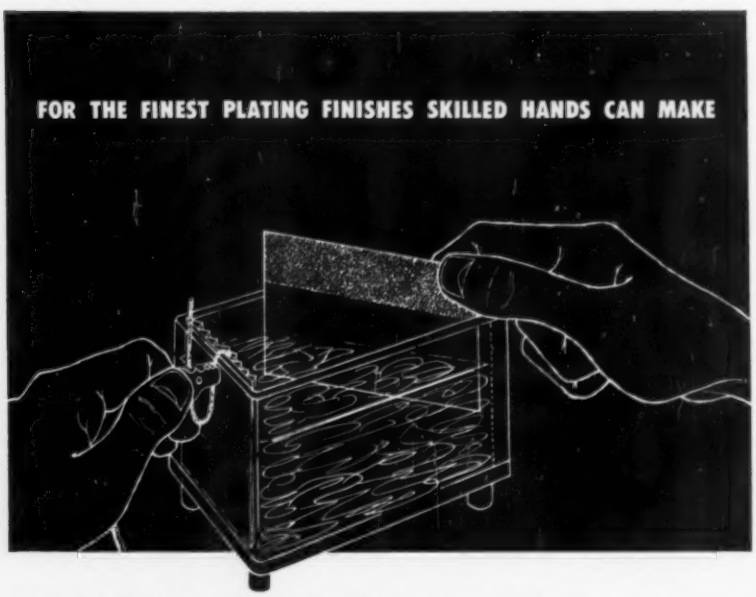
The tungsten-iron alloy was aged at 600, 700, 800 and 900° C. (1110, 1290, 1470 and 1650° F.) and the molybdenum-nickel alloy at 450, 540 and 600° C. (840, 1005 and 1110° F.) and length changes observed on 2-in. long specimens in a quartz dilatometer. The observed amounts of contraction were compared with calculated values assuming the precipitation of the intermetallic compounds Fe_2W and Ni_4Mo. There was good agreement between calculated and measured values at the highest temperatures of equilibration. Large disagreements existed at low aging temperatures at which equilibration times were probably much larger than those employed.

Tungsten-iron and molybdenum-nickel alloys which had been solution treated were creep tested at 600° C. (1110° F.), the former at 5000 and 10,000 psi., the latter at 5000 and 7500 psi. At both stresses for the tungsten-iron alloy, negative creep was observed as expected on the basis of the dilation data.

The data emphasize that entirely different creep rates can be obtained depending on whether a phase change takes place during or prior to creep testing.

Normally, in a relaxation test, at constant strain relaxation effects a decrease in stress as a consequence of creep, that is, the original elastic strain is in effect exchanged for plastic strain with time. However, negative creep might be expected to produce a stress increase. To test this idea, the molybdenum-nickel alloy was subjected to relaxation tests. In one test, the initial stress of 5000 psi. applied to the solution-treated specimen at 600° C. (1110° F.) increased 1.4 times after about 25 hr. exposure. On further holding, this stress increased slowly to about 1.44 times the initial value and began to relax after about 165 hr. Only after 350 hr. had the stress relaxed to the initial value. A pre-aged specimen showed practically no stress build-up.

The practical significance of the effects described is that of structural instability generally, and a tendency for "negative creep" might be of serious consequence in high-temperature bolting applications, or in annealing treatments after cold work because of the build-up of internal stresses which could lead to cracking. GORDON D. GEMMELL



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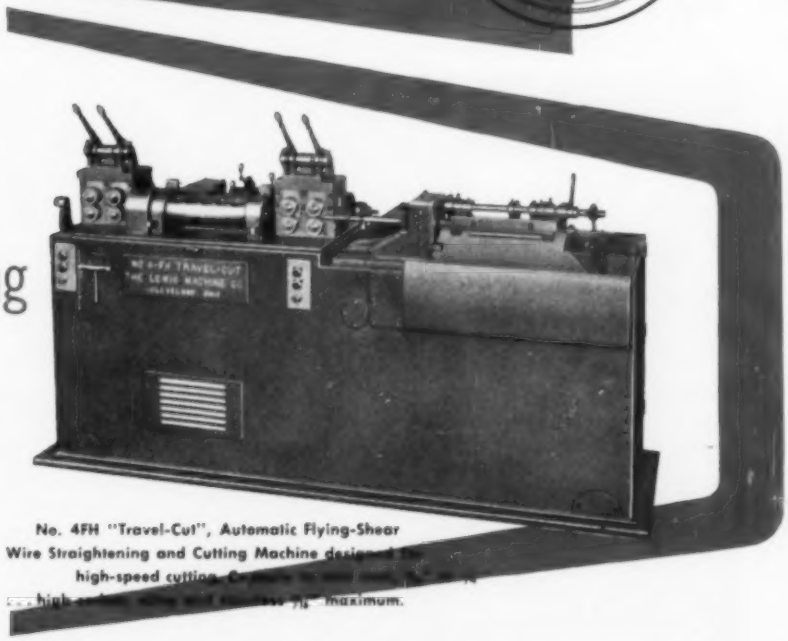

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Aging Characteristics of Hastelloy B

Digest of "Aging Characteristics of Hastelloy B", by R. E. Clausing, P. Patriarca and W. D. Manly, ⊜ Preprint No. 79, 1958.

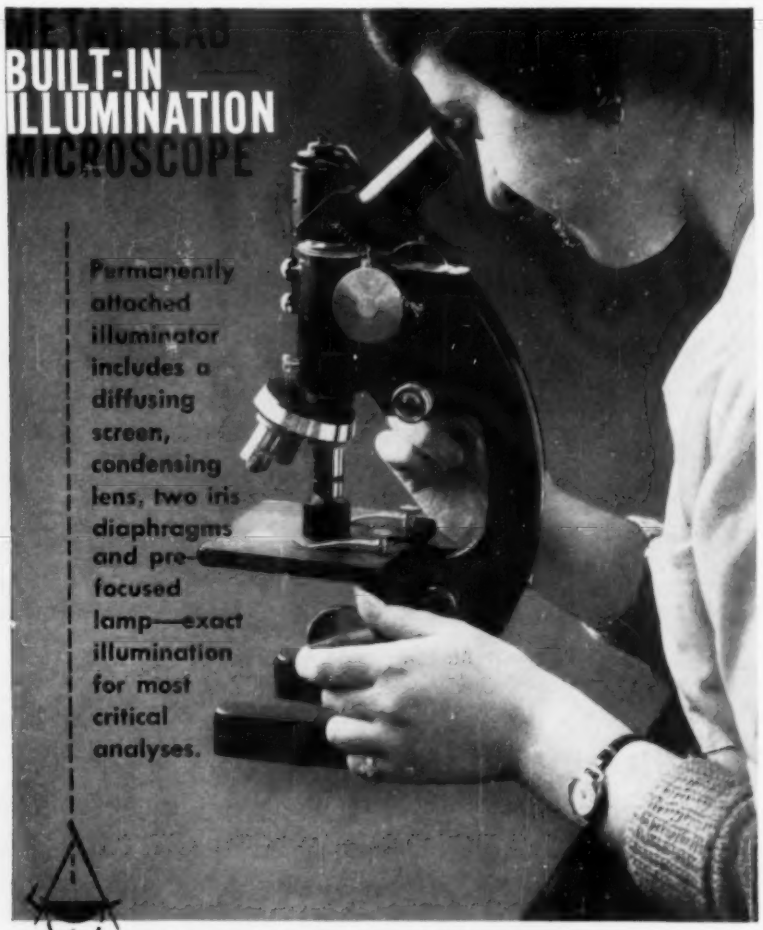
THE ALLOY Hastelloy B (66 Ni, 27 Mo, 5.5 Fe, 0.6 Cr, 0.6 Si, 0.035 C) was examined after aging to determine the metallographic changes. The tensile strength and ductility were also determined for specimens aged for various lengths of time up to 1000 hr. at temperatures of 1100 to 1600° F. Both room-temperature and elevated-temperature tensile behavior were determined.

There is evidence of precipitation at all temperatures although visible precipitates were observed only after aging at 1300° F. and above. According to the binary Ni-Mo phase diagram, the alloy should precipitate β-Ni_4Mo on aging below 1544° F. and γ-Ni-Mo at 1544 to about 1610° F. The evidence for precipitation at 1100° F. consists of a marked increase in strength and hardness and loss in ductility after 1000 hr. of aging. A minimum in room-temperature ductility occurs after aging of 1000 hr. at 1300° F. The only effect of the precipitation on elevated-temperature properties is a marked loss in ductility on testing at 1300° F.

The first microscopic evidence of precipitation is the appearance of a Widmanstätten precipitate after aging at 1300° F. This structure is still present after aging at 1400° F. but is absent at 1500° F. The precipitate at 1500° F. appears as thick needles or platelets and presumably γ-Ni_3Mo rather than the β-Ni_4Mo present below this temperature. This observation suggests that the $\beta \rightarrow \gamma$ peritectoid temperature is below 1500° F. for the commercial alloy used in this investigation.

The marked loss in ductility with aging at 1300° F. is associated with the Widmanstätten precipitate. The loss in ductility after aging at 1100° F. in the absence of such a precipitate suggests the presence of a submicroscopic beta precipitate.

R. W. GUARD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Identification of Uranium Inclusions

Digest of "Metallographic Identification of Inclusions in Uranium", by G. L. Kehl, Eric Mendel, Emilio Jaraiz and M. H. Mueller, ⊜ Preprint No. 100, 1958.

THE DEVELOPMENT of a method for metallographic identification of inclusions in a metal first requires the determination of the true identity of the inclusions of interest. Second, a procedure must be established that is easy to apply, reproducible, and that gives clear separation between different kinds of inclusions. The present work identifies various inclusions in uranium and describes how to distinguish between them.

Inclusions that can be identified by the scheme described are UN, U(C,N), UC, UH_3, UO, UO_2, and U_6Fe. The inclusions were mechanically removed from specimens, in which one type of inclusion predominated, by using an ultrasonic

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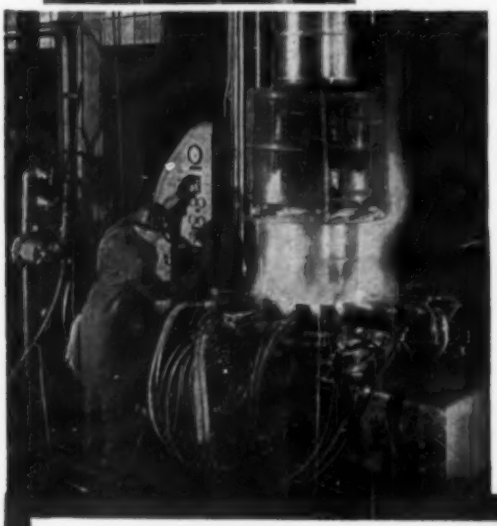

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Uranium Inclusions . . .

"jack-hammer" technique. The crystal structures and lattice parameters of the removed inclusions were determined by X-ray diffraction techniques and the results compared with published values.

The metallographic identification procedure relies mainly on the rate of electrodeposition of copper onto the inclusions and on the character of the deposit at a magnification of 200×. Mechanically polished specimens were immersed in a 1:1 aqueous nitric acid solution immediately before electroplating to secure a standard surface. A copper cyanide solution operated at a current density of 2 milli-amp. per sq. cm. of total surface area and at an open circuit potential of 4 to 6 v. was used to deposit the copper. The copper deposited preferentially on the inclusions in most cases because they are usually cathodic to the uranium matrix. Additional information was obtained by noting the reactivity of the inclusions in the 1:1 nitric acid and upon atmospheric exposure, and by determining their hardness. The most important observations useful for identification are:

Uranium mononitride: This phase receives a continuous copper deposit that is faithfully confined to the inclusion area. It is little affected by the atmosphere and is highly resistant to nitric acid discoloration.

Uranium carbonitride: These inclusions behave similarly to UN, but a continuous copper deposit takes much longer to produce.

Uranium monocarbide: Copper deposits at an even slower rate and the deposit is not continuous. Uranium monocarbide also oxidizes and discolors readily in air and it darkens rapidly in nitric acid.

Uranium hydride: Copper deposits simultaneously on both the uranium matrix and the inclusions at about the same rate. They are unaffected by air and nitric acid and usually exist in irregular stringer shapes or as spheroids.

Uranium monoxide: These inclusions are of questionable composition, possibly being U(C,N,O) with oxygen predominating. They receive no copper deposit whatsoever, and they begin to darken in 1:1 nitric acid after 20 sec. The average hardness of UO is Vickers 900 compared to 730 for U(C,N).

Uranium dioxide: These inclusions also receive no copper deposit, but do not discolor in 1:1 nitric acid.

Intermetallic compound U_6Fe: Copper deposits only after 45 sec. and then as a coarse, granular deposit. The intermetallic compound U_6Fe is unaffected by exposure to air and to nitric acid up to about 30 sec.

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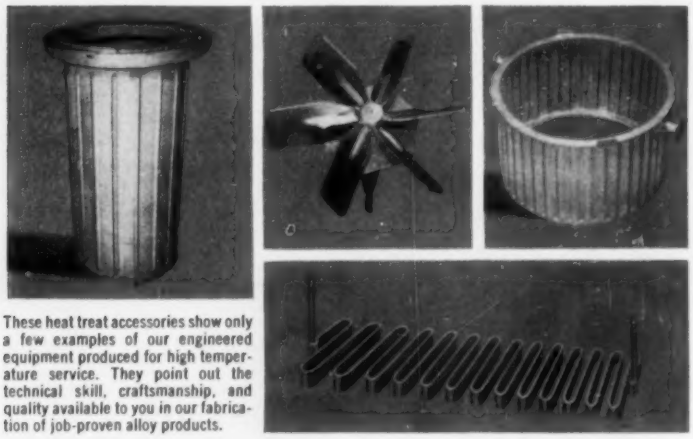

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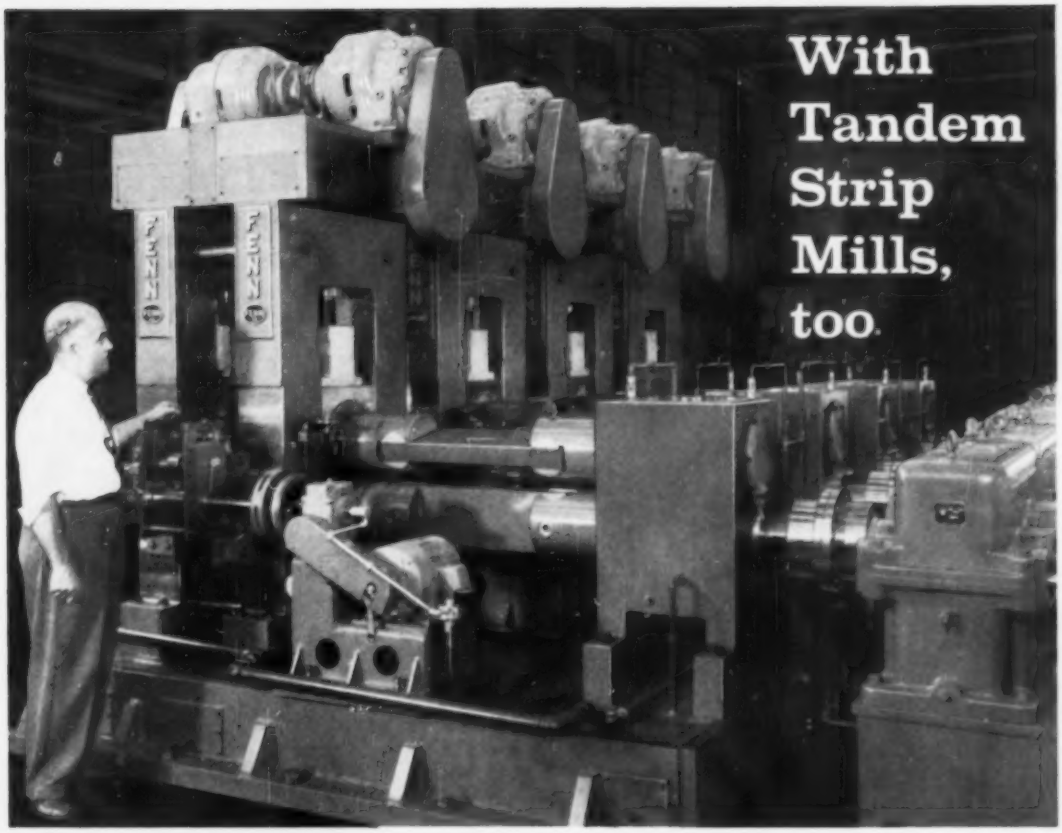

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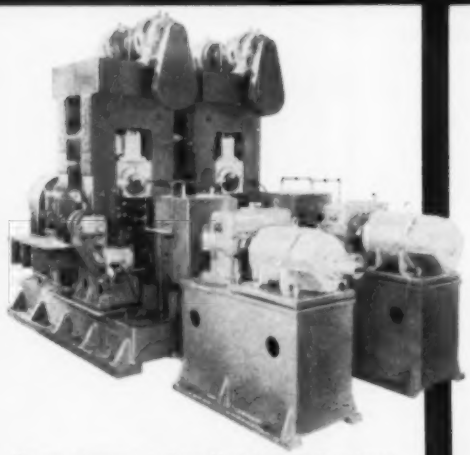

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Steels Containing Copper

Digest of "Effect of Copper on the Heat Treating Characteristics of Medium-Carbon Steel", by R. A. Grange, V. E. Lambert and J. J. Harrington, Preprint No. 62, 1958.

THE EFFECT of copper on hardenability, equilibrium transformation temperatures, temperature range of martensite formation, isothermal transformation, precipitation hardening and softening of martensite on tempering was determined for a 0.45% carbon steel for 0, 0.5, 1 and 1.5% Cu. The hardenability effect of copper can be expressed as

$$F\alpha = 1 + 0.2 \times \text{wt.\% Cu.}$$

Thus the hardenability effect of copper is in direct proportion to the percentage present and copper is less effective than nickel in increasing hardenability.

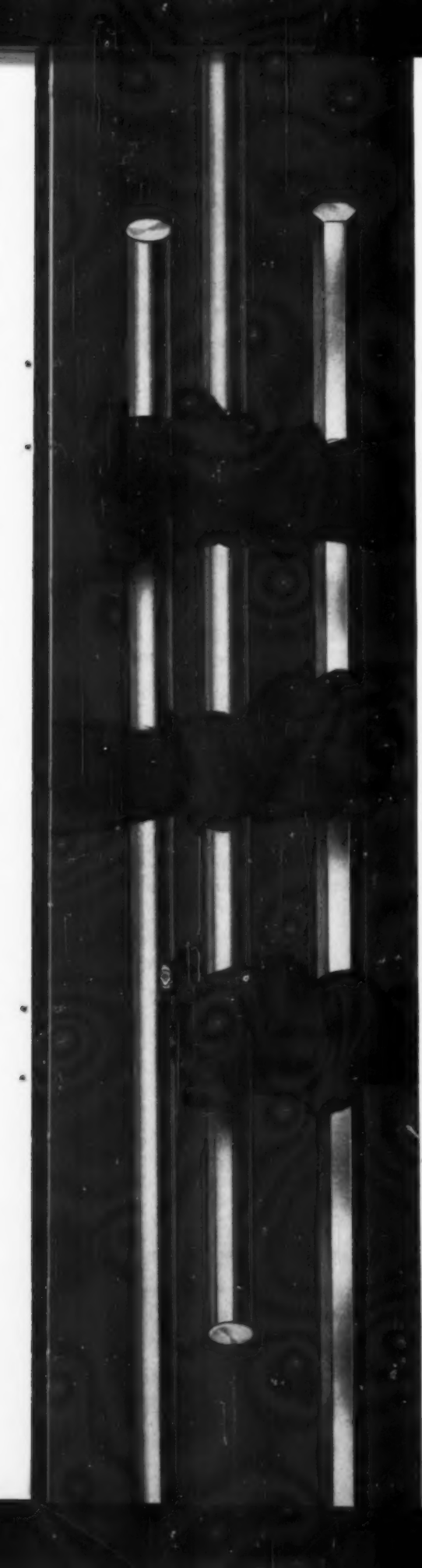
The equilibrium transformation temperature, Ae_3, was lowered in direct proportion to the percentage of copper to the extent of 20° F. for each 1% of copper. The Ae_1 was lowered a diminishing amount as copper increased to 1% with no additional lowering thereafter, at least up to 1.5%. Therefore, the effect of copper upon the equilibrium transformation temperatures is small.

The temperature range of martensite formation showed a small but significant lowering in direct proportion to the percentage of copper. Quantitatively each 1% of copper lowered M_s by 20° F. Thus, copper, like most alloying elements, lowers M_s but its effect is small.

Isothermal transformation diagrams are similar in shape but differ in location on the time scale. That is, copper retarded transformation to about the same extent at all temperature levels. Copper had no marked influence upon the appearance of any of the isothermally formed transformation products. However, copper increases somewhat the amount of pro-eutectoid ferrite in the pearlite region and bainites are more open.

In practice, copper steels are sometimes hardened and strengthened by normalizing and then tempering to induce precipitation, which results in a substantial increase in strength, especially in relatively low-carbon structural steels.

Curves showing the change in hardness with tempering time at each



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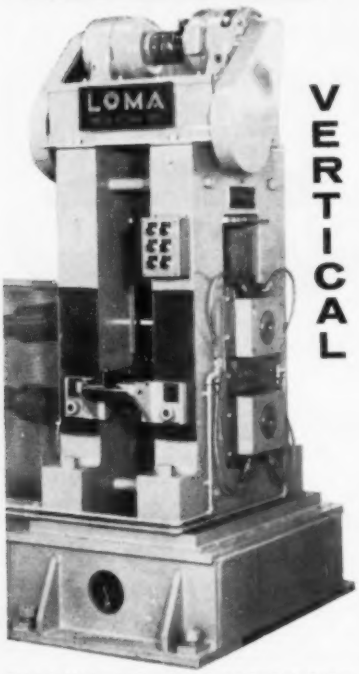

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Copper Steels . . .

of four tempering temperatures are typical of those found in other precipitation hardening alloys. These curves indicate no precipitation hardening until more than 0.5% Cu was present.

Copper conveyed a resistance to softening on tempering martensite. The effect was much greater at higher tempering temperatures. Furthermore, the effect was not directly proportional to the percentage of copper present, but was small with only 0.5% Cu, and increased markedly between 0.5 to 1.0% Cu.

The effect of copper up to 1.5% on the heat treating characteristics of 1045 steel was generally beneficial. However, the magnitude of its effect was usually so small that relatively large percentages would be required to obtain an appreciable effect. Thus, the advantages to be gained from the addition of copper to steels for use in a fully heat treated condition probably do not offset its disadvantages, namely, increased difficulty in hot working and inability to remove copper from scrap. Up to now, copper has not been used as a substitute alloying element in A.I.S.I.-S.A.E. type steels, nor does it seem likely that it ever will be used for this purpose unless desirable interaction effects between copper and some other alloying elements are subsequently discovered. On the other hand, small residual percentages of copper appear to be comparatively innocuous as far as heat treating characteristics are concerned and can be ignored in planning heat treatments. This would seem to be essentially true also for steels to which up to 0.5% Cu is added intentionally to improve resistance to atmospheric corrosion.

D. J. GIRARDI

Carbide Phases Produced in High-Carbon Steel

Digest of "Magnetic Analysis of Phase Changes Produced in Tempering a High-Carbon Steel", by Morris Mentser, Preprint No. 66, 1958.

USING a modified pendulum balance for measuring magnetic moment, an investigation was made of the carbide phases formed during

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Carbide Phases . . .

tempering of quench hardened, high-carbon (1.6% C) steel.

Specimens were austenitized in an argon atmosphere for 2 hr. at 1100° C. (2030° F.) and quenched in a 10% sodium hydroxide solution. The quenched disks were sealed in individual evacuated pyrex tubes to prevent oxidation during subsequent tempering treatments. Some of the samples were treated in liquid nitrogen before tempering to reduce the amount of retained austenite.

For quantitative analysis of phases formed during tempering, knowledge of specific magnetizations of initial, intermediate and final phases is needed. These were determined prior to tests on the quenched specimens. The specific magnetizations of cementite and ϵ-iron carbide were obtained as functions of both magnetic field strength and temperature on carbides prepared by carburizing finely divided iron with carbon monoxide. These data provided the basis for calculating the identity of the carbide phases in tempering the quenched alloy.

The results of this carefully planned experiment showed that hexagonal carbide (ϵ-iron carbide) forms on initial decomposition of retained austenite in the second stage of tempering, at 230° C. (445° F.) or lower. Thus, at these temperatures, the transformation product of retained austenite, that is, bainite, is initially an aggregate of ferrite and hexagonal carbide, and not ferrite and cementite. The composition of the hexagonal carbide, derived from magnetic measurements, was approximately $Fe_{2.5}C$. Subsequent transformation of the hexagonal carbide into cementite was found to occur largely in the third stage of tempering by reaction with ferrite and/or low-carbon martensite.

G. H. Enzian

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Mechanical Properties of Fe-Al-Si Alloys

Digest of "Mechanical Properties of Fe-Al-Si Alloys at Room and Elevated Temperatures", by D. J. Schmatz and V. F. Zackay, Preprint No. 111, 1958.

The Fe-Al-Si ternary is metallurgically very appealing. Alloys in the solid-solution region have good oxidation and high-temperature corrosion resistance, and high electrical resistivity; they are also very cheap. Unhappily, however, the ductility of the alloys is poor.

In this paper, the mechanical properties of a series of alloys in the iron-rich corner of the ternary were investigated. Silicon (up to 2.5%) was used as the independent variable, the aluminum being held at 5, 7 and 9 wt.%. At constant aluminum content, the yield and tensile strength increase with increasing silicon content, but with a rapid decrease in ductility. The tensile properties are insensitive to the heat treatment of the alloys (slow cooled and quenched) for low annealing temperatures (1400° F.), but alloys slow cooled from higher temperatures (1500° F.) show a drastic reduction in ductility compared to the quenched specimens, due to grain boundary precipitation of carbon.

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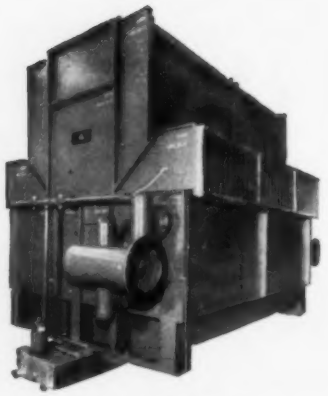

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Fe-Al-Si Alloy . . .

increases the stress for 100-hr. rupture in all alloys, but at the expense of ductility. The resistance to deformation at high temperatures is poor, except for alloys of high solute content (9 Al, 2.5 Si), in which long-range order is probably retained to a high temperature.

The presence of long-range order was qualitatively indicated by changes in the electrical resistivity with alloy content. Silicon appears to be additive to aluminum in initiating order at low aluminum contents. At higher aluminum-silicon contents, the order-disorder transformation temperature seems to be significantly increased by the presence of silicon. As expected, alloys in the ordered region show a decreased creep rate.

The oxidation resistance was found to be strongly improved by the addition of silicon.

G. M. McMANUS

Precipitation Hardening of an Iron-Base Alloy

Digest of "The Response of an Iron-Base Alloy, Hardened With Titanium, to Various Aging Times and Temperatures", by T. W. Eichelberger, ⊕ Preprint No. 60, 1958.

PRECIPITATION HARDENING has been used for several years as a method for strengthening high-temperature alloys, even though there is some lack of understanding of the effect of various aging treatments on elevated-temperature properties. To provide more complete information on this subject, a study was made of the effects of chemical composition, aging temperature and aging time of an alloy base representing the range of compositions of three separate commercial alloys. These iron-base alloys all contain 20 to 30% Ni, and 13 to 16% Cr in addition to minor amounts of other elements. The alloys are hardened by the use of titanium from 1.3 to 2.5%. The series of alloys studied covered the entire range of titanium, molybdenum, and contents used in the commercial alloys.

No attempt was made in this work to investigate thoroughly the effect of the solution treatment tempera-

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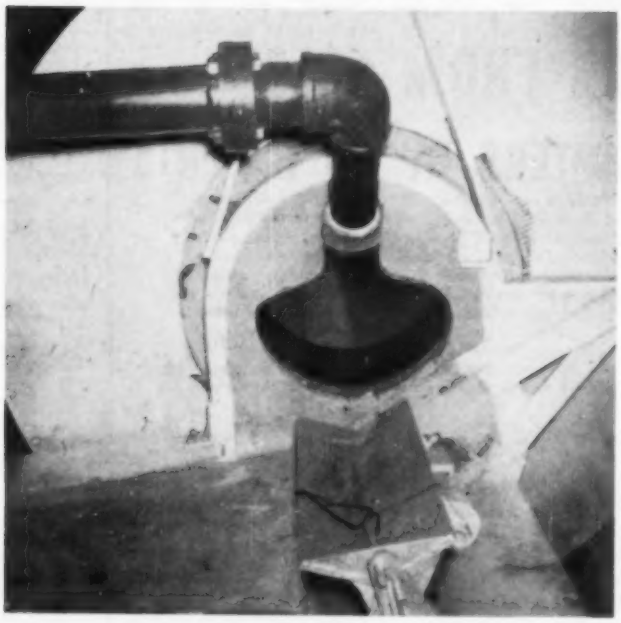

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Hardening . . .

ture on the aging reaction, nor the effect of complex aging treatments. The effect of aging time from 1 to 512 hr. was studied at aging temperatures from 1100° to 1600° F. after a solution treatment of 1 hr. at 1950° F. The course of aging was measured by Vickers hardness tests. From the mass of data obtained, master curves were plotted showing hardness as a function of time, temperature and composition; the maximum hardness obtainable as a function of aging temperature and composition; and the time required to reach maximum hardness as a function of temperature.

Analyses of the data show conclusively that "soluble" titanium contents (total Ti = 4 × percent carbon) below about 1.3% do not produce sufficient precipitation hardening to be of practical importance. Molybdenum contents above 2¼% produce additional hardening at temperatures higher than 1400° F. However, vanadium in the range covered in this work (up to 0.50%) did not affect the aging reaction.

G. H. ENZIAN

Hydrogen-Induced Delayed Failure in Titanium

Digest of "Hydrogen Embrittlement and Delayed Failure in Titanium Alloys", by R. D. Daniels, R. J. Quigg and A. R. Troiano, ⊕ Preprint No. 86, 1958.

THE DELAYED FAILURE of 4 Al, 4 Mn titanium alloy C-130 AM, caused by hydrogen, was studied. The relation of the time for failure to microstructure and test temperature was examined. Three structures of the same strength level (140,000 psi. tensile strength) were produced by (*a*) quenching, (*b*) quenching and aging, and (*c*) slow cooling. These three structures varied in the amount of alpha from 55% for (*a*) to 75% for (*c*). The susceptibility to delayed failure was proportional to the amount of alpha present. Measurements of electrical resistance changes during the time of test showed that creep occurred in some of the materials prior to the formation and growth of the cracks.

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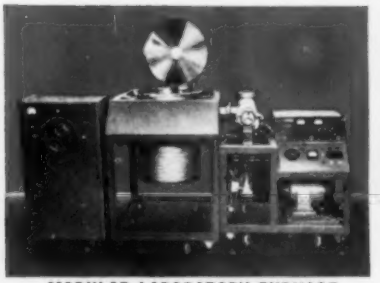

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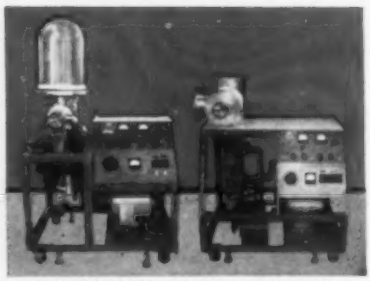

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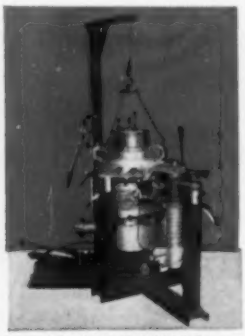

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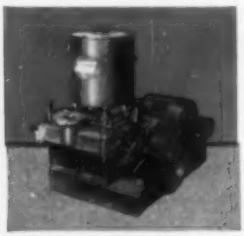

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Delayed Failure . . .

The quenched specimen containing the smallest amount of alpha showed the least susceptibility to delayed failure. This observation may be related to the fact that the structure with the most beta has the largest capacity to dissolve hydrogen because of the larger relative solubility in the beta phase. The structure also changes from one having continuous beta matrix to one where alpha is continuous. The latter structure would also be expected to show greater susceptibility to fracture.

The time required for failure was measured at temperatures from −321 to +300° F. Unfortunately, the time is shortest at room temperature.

The process can be described on the basis of the formation and growth of cracks. The effect of hydrogen is in the crack initiation step while the role of temperature influences the crack growth at high temperatures and the hydrogen diffusion at low temperatures. Plastic strain by creep lowers the susceptibility to cracking.

R. W. Guard

Evaluating Deep Drawing Qualities of Sheet Metals

Digest of "The Assessment of the Drawing and Forming Qualities of Sheet Metal by the Swift Cup-Forming Test", by O. H. Kemmis, *Sheet Metal Industries*, March 1957, p. 203-208; April 1957, p. 251-255.

Experience has shown that simple cupping or tensile tests are inadequate for evaluating the deep drawing properties of sheet metals. They fail because the fundamental factors involved in complex drawing operations are not completely understood, and also because of the variations in forming operations encountered commercially. Consequently, it is necessary to resort to simulative rather than scientific testing procedures to measure drawing and forming properties in the laboratory. The Sheet Metal Working Committee of the British Iron and Steel Research Assoc. proposes a cup-drawing procedure for this purpose. The test was named for H. W. Swift who proposed the procedures after

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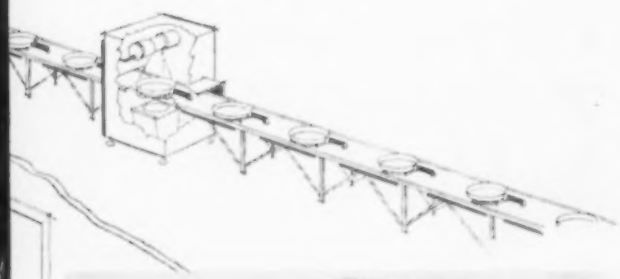

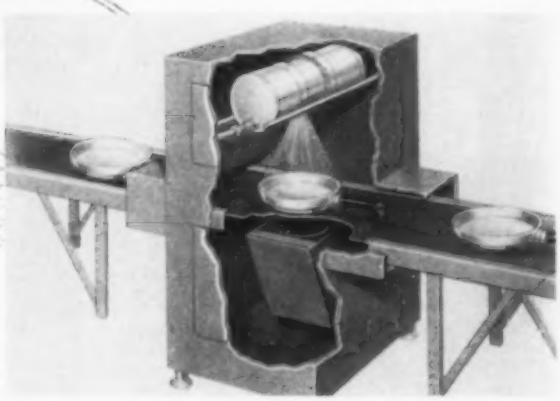

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long study of the subject.

The techniques and precautions recommended in this article are based on a nine-year investigation. Parallel work by the Research Committee of Jernkontoret (Sweden) was taken into account. Consequently, the proposed, standardized testing procedure for cup-drawing tests will be a joint recommendation offered for approval by comparable organizations in other countries.

The proposed testing procedure evaluates sheets on the basis of the maximum blank diameter which can be drawn into a cylindrical cup, under standardized conditions, without breaking. The rating of a material is expressed as the limiting drawing ratio (LDR) which is equal to the ratio of maximum blank diameter to cup diameter. Single blanks of appropriate sizes are used to determine, approximately, the limiting drawing ratio. Then the LDR is determined precisely by making five replicate tests at each of the appropriate maximum and adjacent blank diameters. To insure consistent results by different laboratories, testing must be carefully standardized.

The blanks should be clean, free of burrs and have 0.02 in. removed from their edges by turning or grinding. They should have diameters appropriate for producing increments of 0.025-in. drawing ratios. The punch and dies should be hardened to Rockwell C–60 minimum, and have a surface roughness of 20 μ or less (center-line system). The drawing speed should not exceed 7 ft. per min.

The suggested procedure calls for testing with a flat-headed punch. A punch diameter of 32 mm. $(+0 -0.05)$ and an edge radius of 4.5 mm. (± 0.1) is recommended for sheets 0.3 to 1.2 mm. thick. Alternatively, a 50-mm. $(+0 -0.05)$ punch with a 5.0-mm. (± 0.1) radius may be used for sheets 0.45 to 1.2 mm. thick. The author concluded that cup-drawing tests with flat-headed punches do not rate materials correctly for operations involving stretching of metal over the punch face. Thus procedures for using other punch-head shapes are contemplated.

The dimensions (in mm.) tentatively recommended for dies to be used with the 32-mm. punch are:

Sheet Thickness	ID of Die	Die Radius
0.30–0.43	33.20+0.05	4.3±0.1
0.43–0.61	33.72	6.1
0.61–0.87	34.44	8.7
0.87–1.24	35.48	12.4

To allow for blank thickening during drawing, the radial die clearance should be 40 to 100% more than the original blank thickness. The blankholding loads should be constant within ± 5% and 50 to 75% higher than that necessary to prevent wrinkling. Blanks should be centered to within 1% of the punch diameter. The maximum eccentricity between die and blankholder should be 5% of the minimum sheet thickness. The proposed standard cup-drawing test procedure describes the characteristics of the mineral oil and additives to be used as the drawing lubricant. It recommends that the application be by immersion and draining to insure uniformity. (*Continued on p. 274*)

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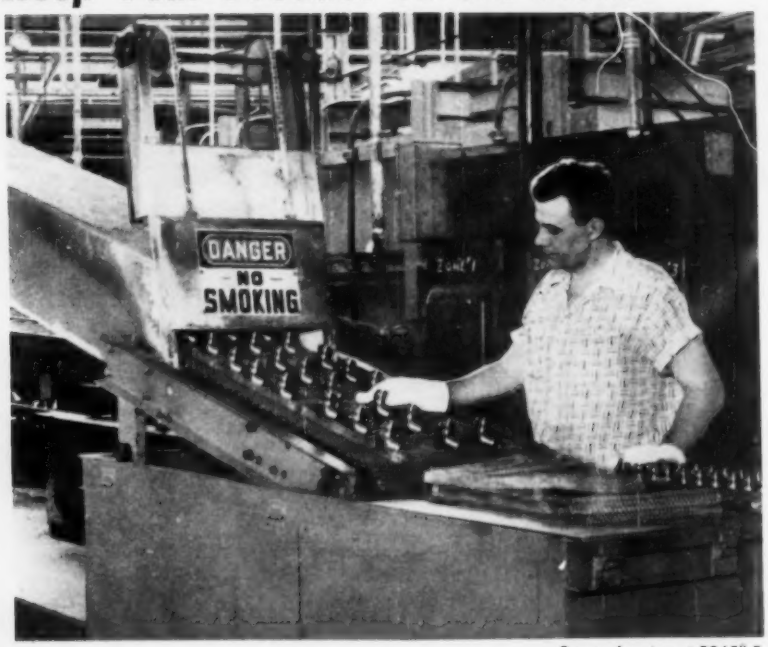

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Deep Drawing . . .

The author presents information on the commercial press performance of 104 lots of sheet steel and the cup-drawing test ratings of samples representing each lot. The drawing operations were severe enough to require extra deep drawing grades of steel for satisfactory operation. The ratings of materials determined by cup-drawing tests correlated with press-shop results at least as well as other tests with longer histories. The few cases of disagreement could be caused by sampling difficulties. In this study, the limiting drawing ratios determined by round-bottom cups agreed better with shop data than did ratings based on flat-bottom cups. Nevertheless, the rankings determined with the two types of punches were highly correlated. The cup-drawing test indicated that aluminum-killed sheet steels were superior to rimmed steel. This finding corroborated opinions based on shop experience but not shown by tensile tests. F. W. BOULGER

Welding Nickel and Nickel Alloys

Digest of "Practical Welding Metallurgy of Nickel and High-Nickel Alloys", by George R. Pease, *Welding Research, Welding Research Council*, Vol. 22, July 1957, p. 330-334.

THIS PAPER includes a complete review of the art of welding nickel and nickel alloys. In particular, it describes the effects upon weldability of various elements which are commonly present in nickel and nickel alloys. Only columbium and magnesium have a beneficial effect upon the weldability, whereas lead, sulphur, phosphorus, zirconium and boron are all extremely harmful. In addition, manganese, copper, chromium, iron and cobalt have no major effect upon the weldability of nickel, and aluminum, titanium, carbon, molybdenum and silicon all have variable effects.

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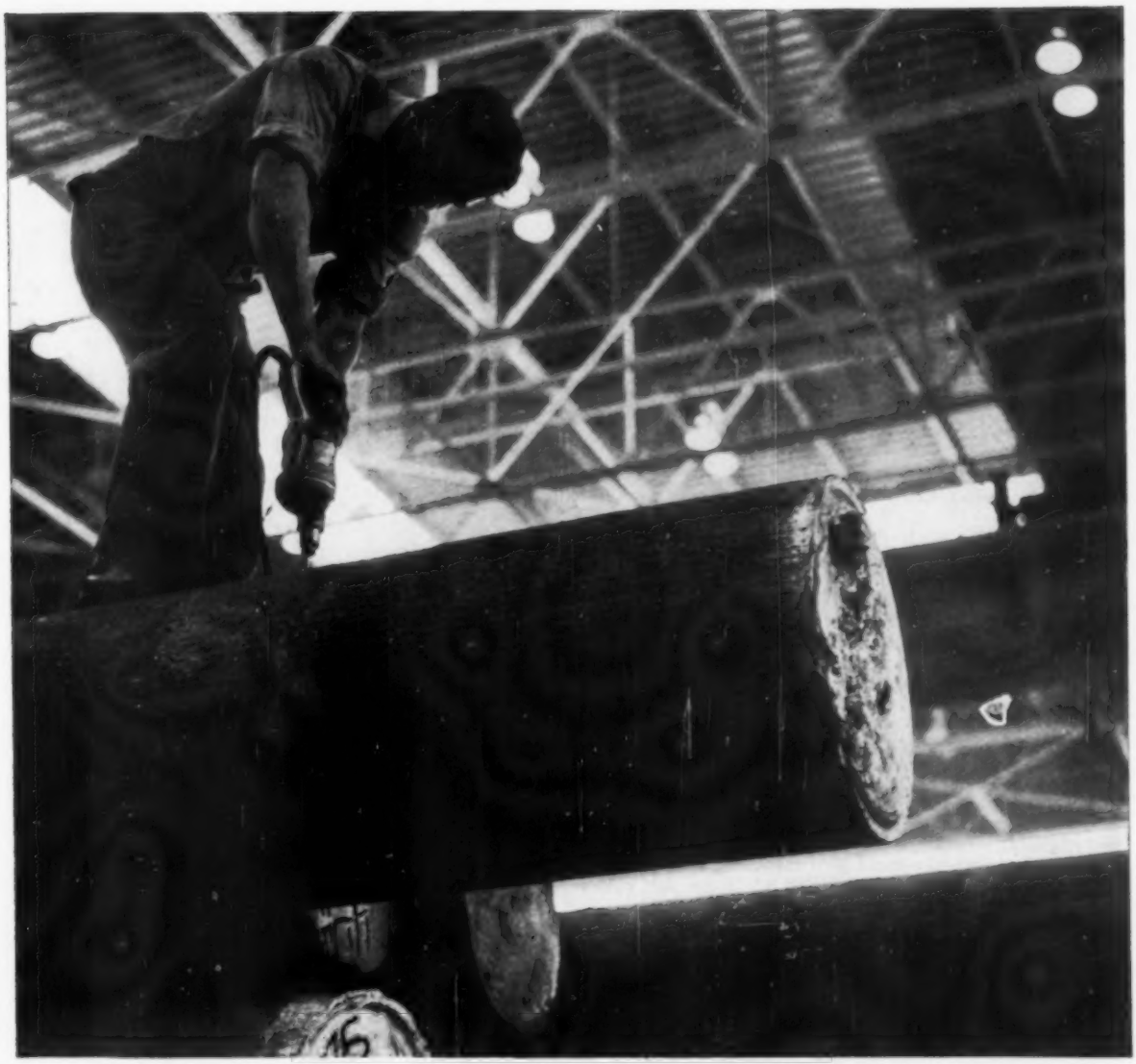

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Welding Nickel . . .

the alloy reacts as does pure nickel so long as nickel remains the major constituent. However, even in 90-10 Cu-Ni alloys, deoxidizers similar to those used for high-nickel alloy welds must be used.

Chromium, the second of the major alloying elements, causes high-nickel alloys to hot crack when other elements, notably silicon, are present. Because of the strong tendency for chromium to form stable oxides and nitrides, such alloys are normally relatively free from porosity. Similarly, the presence of iron, another major alloying element, is not detrimental to weldability; however, iron additions are normally made as ferro-alloys which contain residual quantities of sulphur, phosphorus and possibly oxygen, all of which are deleterious to weldability. Cobalt, also a major alloying element, has no effect when present in very small quantities. Sufficient data is not available concerning the effect of large quantities of cobalt. Molybdenum, the last of the major alloying elements, produces a two-phase system when present in larger quantities. Alloys containing 20 to 30% molybdenum are somewhat crack sensitive, whereas, in single-phase nickel-molybdenum alloys, the crack sensitivity is reduced.

Carbon, a minor alloying element, has a variable effect upon the weldability of nickel alloys depending upon the presence of other elements. However, graphitic carbon present in the heat affected zone is normally found intergranularly and, therefore, presents a structure which is weakened and may fail in service.

As in the instance of iron-base alloys, titanium and columbium preferentially deplete the carbon content of chromium-bearing high-nickel alloys; however, sufficient stabilization to insure adequate corrosion resistance does not always occur. The effect of manganese can usually be ignored unless the concentration is well in excess of 4%. However, in nickel-chromium weld metals containing about 25% iron, the resistance to weld hot cracking is sometimes attributed to the presence of manganese.

Another minor alloying element, magnesium, forms a stable high-melting sulphide preferentially to the extremely low-melting nickel sulphide eutectic. This property of sulphur fixation is normally more effective on inert-gas-shielded welding than in metal-arc welding with coated electrodes due to the high loss of magnesium in the latter.

Silicon, one of the more detrimental of the minor alloying elements, normally increases the hot cracking tendency. Columbium is added in quantities of 4.5 to 8 or 9 times the silicon content to counteract its effect. Zirconium-nickel alloys are classified as being non-weldable due to the extremely high hot crack sensitivity induced by only a few tenths of 1%. Aluminum is added to act as a deoxidizer, but when it is present in sufficient quantities, the hot cracking sensitivity is increased. Titanium, which is added to reduce porosity can, in

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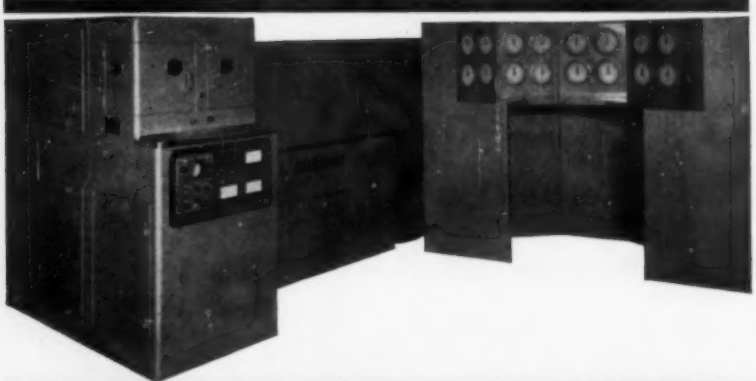

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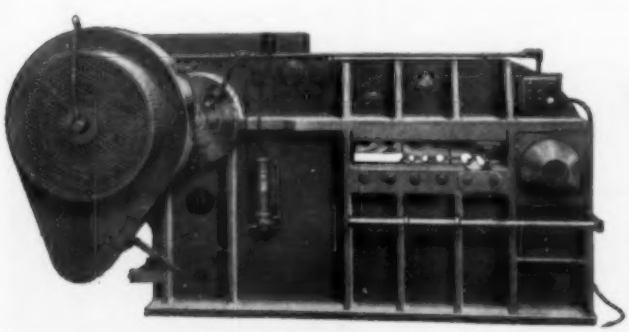

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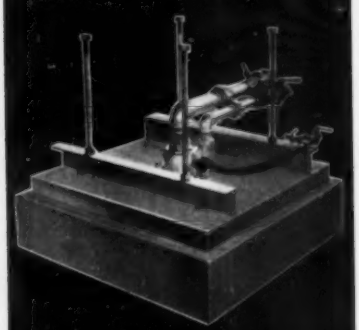

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Welding Nickel . . .

larger quantities, behave in a manner similar to aluminum.

Additions of boron in the range of 0.03 to 0.10% improve high-temperature mechanical properties, but weld metals become very hot crack sensitive. Sulphur, another extremely deleterious element, is very dangerous because it may be introduced into the weld metal by such innocuous items as crayon markings and cutting lubricants. The presence of sulphur results in the formation of intergranular sulphide films. Lead is about as dangerous as sulphur, but because of the very much smaller opportunity for contamination by lead, damaged welds are much less frequent than those caused by sulphur. Phosphorus also reacts as does lead and sulphur, causing servere hot cracking.

The gaseous elements, oxygen, nitrogen and hydrogen, are harmful to welds in nickel and nickel-base alloys only insofar as porosity is concerned.

M. L. KOHN

Mechanically Polished Surfaces

Digest of "The Nature of Mechanically Polished Metal Surfaces — Deformation Produced During Abrasion of 18-8 Type Austenitic Steel", by L. E. Samuels and G. R. Wallwork, *Journal* of the Iron and Steel Institute, Vol. 186, June 1957, p. 211-218.

IT IS WELL KNOWN that the structure of metallographic specimens at the surface to be examined is often seriously affected by the cold working involved in cutting and polishing the surface. The results of an Australian study of the magnitude of these effects produced by various methods of machining and abrasion on an austenitic stainless steel have recently been published. The steel contained 0.06% C, 19% Cr and 10.5% Ni, and was in the form of a ½-in. round bar. Discs cut from this bar were quenched from 1920° F., heavily pickled, and polished by a method known to produce surfaces completely free from deformation effects.

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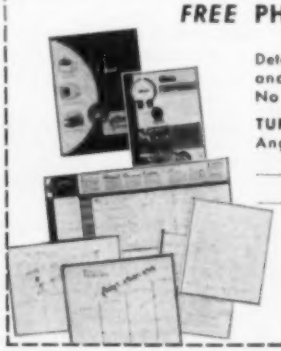

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WRITE DEPARTMENT 8-B

Polished Surfaces . . .

and emery papers, both fresh and used, with an approximately constant pressure around 500 g. per sq.cm. Subsequently, they were prepared for examination by a special method of taper sectioning and polishing, described in previous papers to which references are given, that enabled the depth of disturbed metal below the abraded surface to be measured accurately after electrolytic etching in 10% oxalic acid. The deformation of the stainless steel used in this investigation was clearly shown by the appearance of parallel dark streaks of martensite after this etch. Tests of the steel cold compressed various amounts indicated that this appearance is first detected after 1% compression and becomes steadily more prominent after compressions up to 30%.

Photomicrographs, illustrating the deformation detected in this way below the abraded surfaces, show a very thin superficial layer heavily deformed, and beneath it a thicker layer with comparatively low strains. Both scratch depth and the thickness of the deformed layer were greater with fresh than with worn abrasive paper, but after use for a few hundred strokes longer use made very little difference. Using lighter pressure in the abrasion also made no significant difference in the depth of scratches or deformation. Tests of various grades of abrasive paper indicated a deformation depth about 5 to 10 times higher with silicon-carbide papers than with emery papers of corresponding fineness. With coarser grades, No. 220 or 1/0, the scratch depths were nearly the same for both kinds of paper, and also the deformation depths; but with finer grades, No. 600 or 4/0, the depth values for silicon-carbide were much less than for emery, even though abrasion was 10 times faster. A wax lap containing 10 to 20μ alumina gave much shallower scratches and somewhat shallower deformation than the 600-grade silicon-carbide paper, with an abrasion rate intermediate between it and the 4/0 emery paper.

The deformation produced by various machining methods of preparing flat metallographic specimens was also studied in the same way.

(*Continued on p.* 282)

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Polished Surfaces . . .

Filing and turning gave two deformed layers as described above for abrasion, but the amount of martensite indicated a magnitude of deformation strain exceeding that produced by 20% compression. Grinding produced a confused and irregular deformed structure interpreted as austenite, which would imply that the steel near the surface had reached a temperature above 390° F. to transform the streaks of martensite formed mechanically. Evidently mere abrasion does not produce such temperatures except perhaps very superficially.

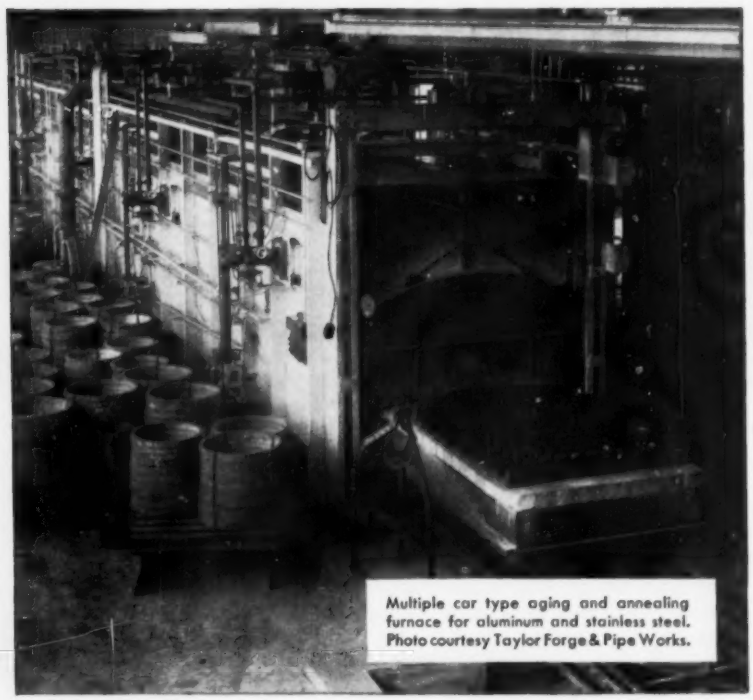
These machining processes gave deformed layers 34 to 46μ deep, comparing with 2 to 6μ for the metallographic abrasive papers. Abrasion with 100 or 150-mesh belts gave deformed layers 12μ thick.

When abrasive papers are fresh, they produce deformation layers that are too deep, and when too worn, the abrasion rate is too slow. Thus they work best when middle-aged. A comparison of the data on abrasion rates and scratch and deformation depths for the various grades of paper shows that, a half minute on each paper is generally sufficient to remove the metal deformed by the previous paper. But a period only twice as long as the time required to remove pre-existing scratches is inadequate.

Final polishing on a napped cloth wheel, driven at 300 rpm. using about 200 g. per sq.cm. pressure, was also studied. The polishing rates for various media ranged from about 6μ per min. for 600-mesh alumina to less than 0.1μ per min. for magnesia. Fine diamond powder was somewhat less efficient than the 600-mesh alumina. For removal of the abrasion deformation 1.5 to 2.5μ deep, produced by fine silicon-carbide paper or the wax-alumina lap, 0.3 to 0.4-min. rough polishing with fine diamond or 600-mesh alumina powder was required. Corresponding times with levigated alumina (0.1 to 0.3μ) were 1.5 to 5.1 min., with magnesia over 15 min., and with electrolytic polishing using perchloric acid and acetic anhydride 5 min. After abrasion by emery papers, which left a deformed layer 4μ deep, these times were about 2½ times as long. Rough polishing between abrasion and final polishing is therefore recommended for efficient removal of the deformed layer.

Probably much of the disturbed metal that has been found by various metallographers in polished specimens was formed in the preliminary machining. Thus, more attention is urged and some care is necessary during the first abrasion step, where a comparatively fresh coarse silicon-carbide paper should be used, preferably with a mechanized wheel, to give an abrasion rate above 9μ per min. The various steps in the preparation of metallographic specimens, including this first abrasion, should be designed to remove the layer of previously deformed metal, and not merely the previous scratches.

The depth of this layer in various alloys, deformed by similar abrasion processes, is roughly inversely proportional to the hardness. For in-



Multiple car type aging and annealing furnace for aluminum and stainless steel. Photo courtesy Taylor Forge & Pipe Works.

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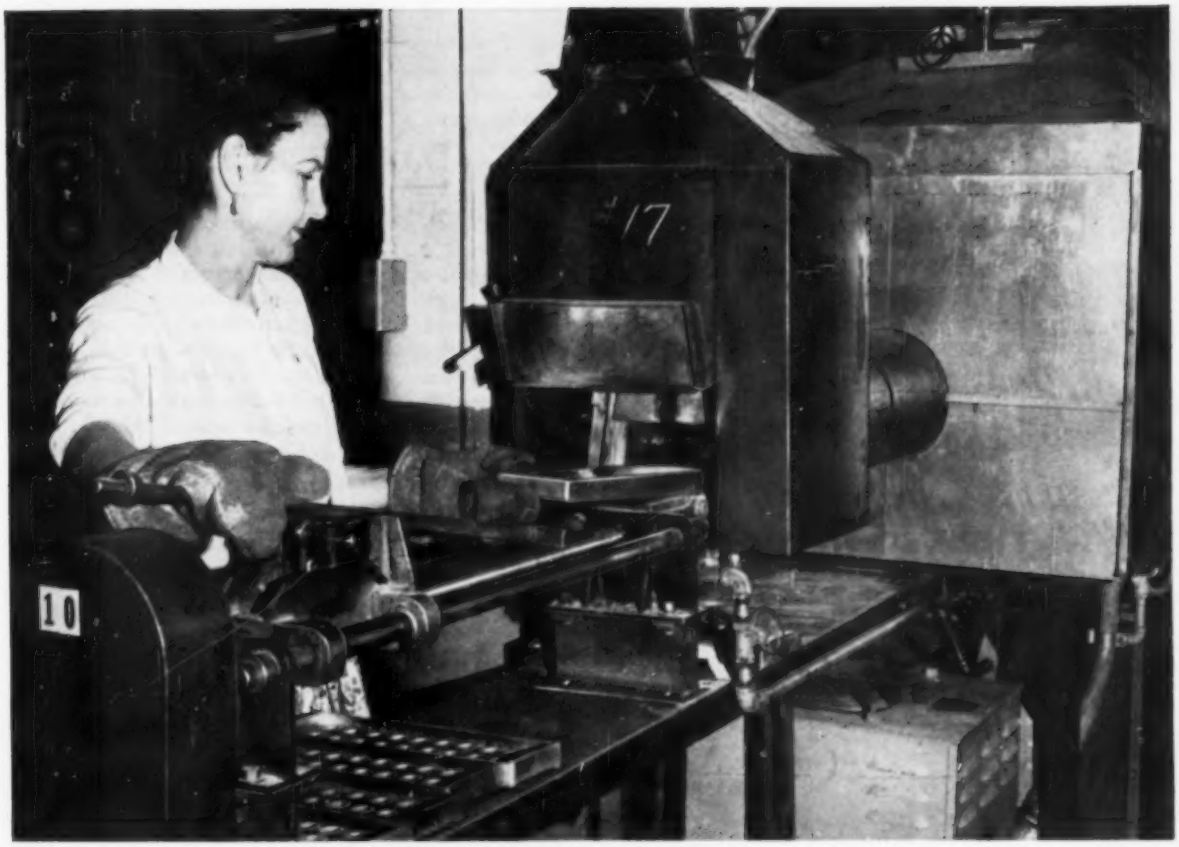

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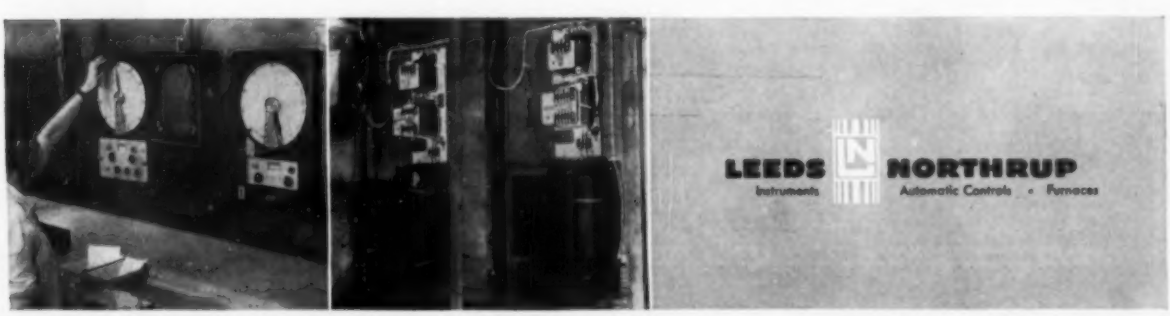

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stance, the steel here discussed was 2.9 times as hard as a 70-30 brass previously tested in the same way, and the deformed layers were three to six times as deep in the brass as in the steel abraded under repectively similar conditions.

GEORGE F. COMSTOCK

Metals at Elevated Temperatures

Digest of "The Engineering Properties of Metals at High Temperatures", by N. P. Allen. Published in BEHAVIOR OF METALS AT ELEVATED TEMPERATURES, Philosophical Library, New York, 1957, 122 p. $6.00.

WRITTEN PRIMARILY for engineers interested as much in the causes of metal degradation in high-temperature environment as in the effects of degradation, this paper serves as an excellent introduction to the complex field of high-temperature metallurgy. The author urges that accessory effects which contribute to metal instability may be as important as ultimate temperature, exposure time, and applied stress levels in predicting behavior.

Materials capable of performing reliably should be selected through careful consideration of changes in metal behavior with temperature. As temperature is raised, the elastic constants, elastic limit, proof stress and tensile strength of typical metals are reduced – slowly at first and then rapidly at higher temperatures. The coefficients of expansion generally rise with temperature. Extensive movement can occur at low loads under high-temperature environment and the resistance of the metal becomes highly dependent on the rate of strain.

Creep characteristics at high temperatures are described as a precarious balance between initial hardening and subsequent softening effects. The softening process is predominent as temperatures or total strains become high. The majority of strain occurring at high temperatures is dislocation movement or ordinary crystal slip. Grain boundary movement is a minor phenomenon in materials having sufficient strength to be of interest to the engineer. The initial distribution of dislocations and the removal rate of work hardening play a great part in creep characteristics and can be varied considerably by slight modification of the material.

For some creep resisting alloys there appears to be an approximate relationship between stress for fracture under steady load in a given time and fatigue stress for fracture using the same time. This fortunate circumstance suggests that materials developed for high creep strength may exhibit desirable fatigue characteristics.

The important concepts of stress fluctuation caused by temperature gradients and changes are also discussed. Under continuous heat flow conditions and elevated loads, creep within a structure may redistribute stresses so that the hottest portion carries relatively little load. Under conditions of thermal shock, such as masses suddenly exposed to a differ-

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Sub-Zero	SZH153	1.5	–95° F.	–85° F.	42"	28"	42¾"	23"	9"	12½"
Sub-Zero	SZH653	6.5	–85° F.	–75° F.	60"	28"	42¾"	47"	15"	16"
Sub-Zero	SZHC657	6.5	–140° F.	–125° F.	60"	28"	42¾"	47"	15"	16"
Rivet Cooler	RSZ503	5.0	–30° F.	–20° F.	42"	28"	41"	30"	16"	18"

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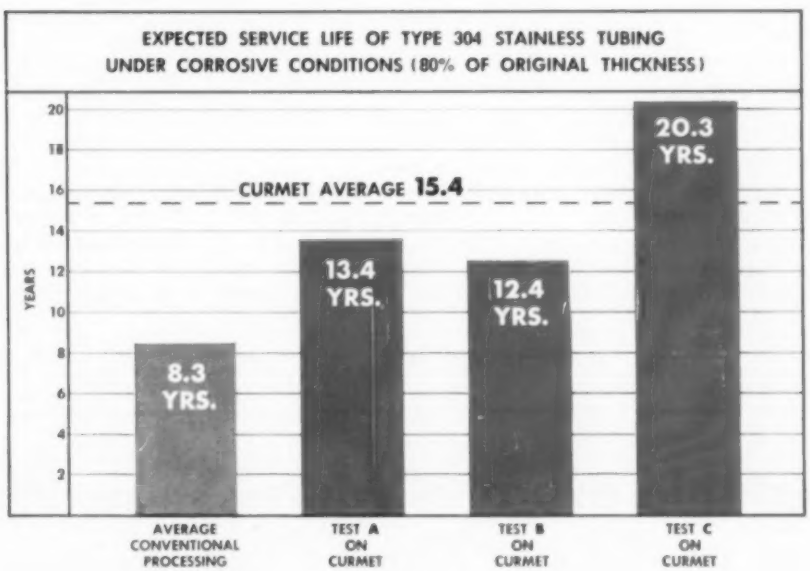

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For the results shown graphically above, test samples of conventionally wrought and CURMET extruded material were subjected to the standard boiling nitric acid (Huey) test in accordance with ASTM specification A-262.

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High Temperature . . .

ent temperature environment, the thermal stresses are greatest at the surface of the mass and are proportional to the temperature gradient. If the material is brittle, fracture occurs at a place and time which can be theoretically approximated by calculation. If the material is ductile, thermal stresses may be redistributed by local yielding. The structure behavior then depends on the ability of the design to accommodate dimensionally the warpage resulting from varying temperatures within the mass. Fracture from thermal stresses in a ductile material would not be expected unless cyclic thermal conditions promote the equivalent of a fatigue test. Ductile materials with the highest fatigue strength are not necessarily most desirable under cyclic temperature conditions, but metals capable of the greatest repeated strain may be preferred.

Metals exposed to high-temperature environments and elevated stress levels are usually also exposed to attack by the environmental atmosphere. This attack may take two forms: solution of the atmosphere components in the metal, or formation of a surface reaction product. For many of the newer alloys, such as chromium, titanium, zirconium and columbium-base alloys, this absorption of atmospheric gases may be vitally significant. No metal has a chance to survive at high temperatures unless any surface scale which forms is continuous, adherent, and resistant to diffusion. Ideally the continuity of the scale should resist cyclic heating and cooling stresses, alternating reducing and oxidizing conditions, and the formation of any product molten at service temperatures. In addition, the ideal surface scale should remain continuous under mechanical deflection or alternating stresses.

Desirable heat resistant metals can be developed by placing obstacles in the way of dislocation movement and elevating the annealing temperature of the metal. Movement of dislocations can be impeded by the precipitation hardening process, but for this to be effective the precipitate must resist both overaging and re-solution at the service temperature. The annealing temperature can generally be raised by alloying with solid solution additions. At present, optimum additions must be found experimentally.

The effect of cold working to increase high-temperature strength depends entirely upon the relation of service temperature to the annealing temperature of the material and the amount of cold work that is used. For high-temperature exposure, cold work may be undesirable because it lowers annealing temperatures.

Generally a coarse grain improves high-temperature strength and creep resistance. At high temperatures, grain-boundary movement, while accounting for only a small portion of total creep, is an important cause of fracture. High-temperature grain-boundary fractures begin at stress concentration points produced by boundary movement. Hard parti-

A notable event of Metal Show Week

will be the 3rd ASM Annual Awards Luncheon to be held Tuesday Noon, October 28, 1958 at Hotel Cleveland's Wedgewood Grand Ballroom. This outstanding Luncheon will be highlighted by fast-paced award ceremonies and a featured speaker. ASM President G. M. Young presides.

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Lithium and the lighter alloys...

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Ballistics is making good use of the ductility, toughness, and very low densities achieved by alloying lithium with magnesium and aluminum. In gages under 1" it has proved to be effective as armor plate, absorbing energy and preventing fragmentation. More important, 1" of magnesium-lithium-aluminum alloy can replace ¼" steel—yet is ⅛ lighter. Dow Chemical's interest in the cubic structure of magnesium-lithium alloy led to modifying the basic binary system by the addition of a third element—aluminum—producing a very high strength-to-weight ratio.

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Jet aircraft traveling 1600 mph at operating altitudes develop "skin" temperatures of approximately 350° F. Conventional aluminum alloys employed in aircraft construction begin to lose physical properties in the 250-350° F. range, limiting their usefulness to speeds below 1300 mph. Stainless steel and titanium are alternate solutions but add immensely to cost and weight of airframe structures. Alcoa's new X2020 aircraft alloy utilizes the rare-earth element lithium to push ahead the thermal barrier in supersonic aircraft by about 100° F. Not only does it serve to maintain aluminum's strength at high temperatures, but this aluminum-lithium alloy is 3% lighter and has 8% greater modulus of elasticity which adds to structural stiffness.

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Lithium is also used as a deoxidizer in the gold melting process to prevent the contamination of molten gold by oxygen in the pouring operation. Metals & Controls found lithium metal a stronger deoxidizer than phosphorus, previously used. Polishing, formerly difficult due to particles resulting from the oxide of phosphorus, was simplified.

Cooperative research on special lithium alloys is available to interested parties under our joint working agreement with Brooks & Perkins, Incorporated of Detroit, fabricators of magnesium and other light metals. Letterhead inquiries should be addressed to our Technical Service—Sales Department.

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High Temperature . . .

cles precipitated in grain boundaries may act as keys delaying boundary movement or the hard particles themselves may be the source of stress concentrations promoting fracture. Grain-boundary fracture is noticeably influenced by minor impurities in the metal. If the impurities are removed, the alloy hardness can be elevated without serious harm to the ductility at high temperatures.

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39 authorities are represented in this volume. Includes the importance of beryllium, reduction to metal, processing, fabrication, brittleness problem, corrosion cermets and ceramics and health hazards. 700 pages – 6x9 – red cloth – $8.00. *Clip and send to ASM Technical and Engineering Book Information Service, 7301 Euclid Ave., Cleveland 3, Ohio.*

Mechanism of Banding

Digest of "The Mechanism of Formation of Banded Structures", by Paul G. Bastien, *Journal*, Iron and Steel Institute, Vol. 187, December 1957, p. 281-291.

SINCE the contributions of Stead (1915) and Howe (1916), it has generally been agreed that the structure known as "banding" in mechanically worked low-carbon steels derives in some manner from dendritic segregation of elements, particularly phosphorus, in the original ingot. Stead's theory postulated that, during cooling through the transformation range, the phosphorus which concentrates in the interdendritic spaces displaces the carbon towards the axes of the primary crystals. In the worked steel, according to this theory, the elongated "bands" higher in phosphorus thus tend to be denuded of their carbon and appear essentially as ferrite (etching white) while the regions which were originally ribs or arms of dendrites are left with more carbon as pearlite.

This explanation appeared to receive support in later years by the demonstration that phosphorus does, in fact, lower the solubility of carbon in alpha iron. However, the theory was hard pressed to explain why the extent or intensity of banding usually diminishes as the cooling rate is increased, but reappears on a fresh heat treatment involving a slow cool. Again, difficulties are presented by the banding occasionally observed in low-phosphorus steels and by structures sometimes noted in low-alloy steels, cooled at particular rates, where pearlite and bainite alternate.

Workers in this present decade, the French notable among them, provided satisfactory modifications and elaborations of Stead's original thesis so that the mechanisms of banding in general can be explained. Mr. Bastien is eminently fitted to review this work as he has figured prominently in many of its phases.

Modern techniques which have thrown light on the problem include

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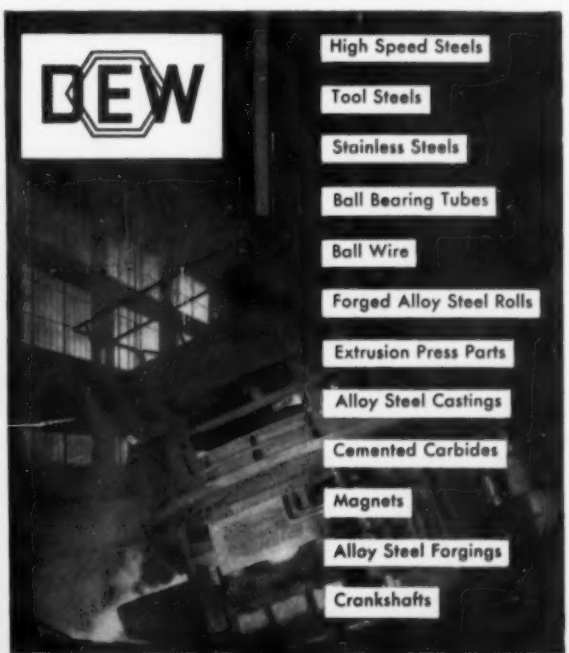

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Banding . . .

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It has been confirmed that in normal low-carbon and low-alloy steels, phosphorus does, in fact, play an essential role in the formation of banding. It does so primarily by raising the A_3 point at which austenite is transformed into ferrite. On slow cooling, regions which were originally interdendritic, containing microsegregations of both phosphorus and carbon, will begin to transform to ferrite before the adjacent regions which were dendritic axes or ribs. The carbon becomes more concentrated in those parts which are still austenitic and when finally transformed are more pearlitic.

Bastien satisfactorily answers the query which may be raised about carbon diffusing away from areas rich in phosphorus and not the phosphorus itself, in terms of the lower activation energy of carbon for diffusion in austenite. Likewise, the question "Why doesn't the ready carbon migration result in a uniform distribution of this element?" is explained by the higher thermodynamic activity of carbon in regions of high-phosphorus content. The carbon atoms tend to migrate to regions of lower activity, even if this leads to an "uphill diffusion".

Since the carbon migration is connected with transformation in a heterogeneous austenite, the migration is not observed when the upper transformation disappears owing to sufficiently rapid cooling. Any element which in solid solution raises the upper transformation point A_3 of the steel (accompanied in some cases by a horizontal displacement of the transformation curve), can give rise to a banded structure. While phosphorus is perhaps the most common contributor to the phenomenon, other elements, particularly arsenic and tin, act in the same way and augment the effect of phosphorus. In low-alloy steels, some of the added elements accentuate and others counteract the effects of phosphorus, arsenic and tin.

During cooling through the transformation range Ar_3 to Ar_1, the segregated elements may help either to reconstitute the original segregation of the carbon at the instant of solidification or they may reverse it.

With certain transformations, the increase in the carbon content of the austenite not yet transformed may be such as to lead to a final heterogeneity apparently more pronounced than that caused by the dendritic segregation at the time of solidification.

HOWARD K. WORNER

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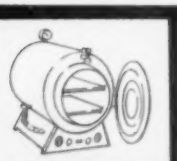
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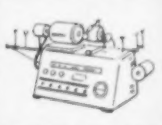
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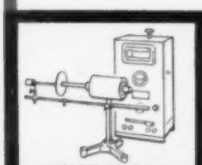
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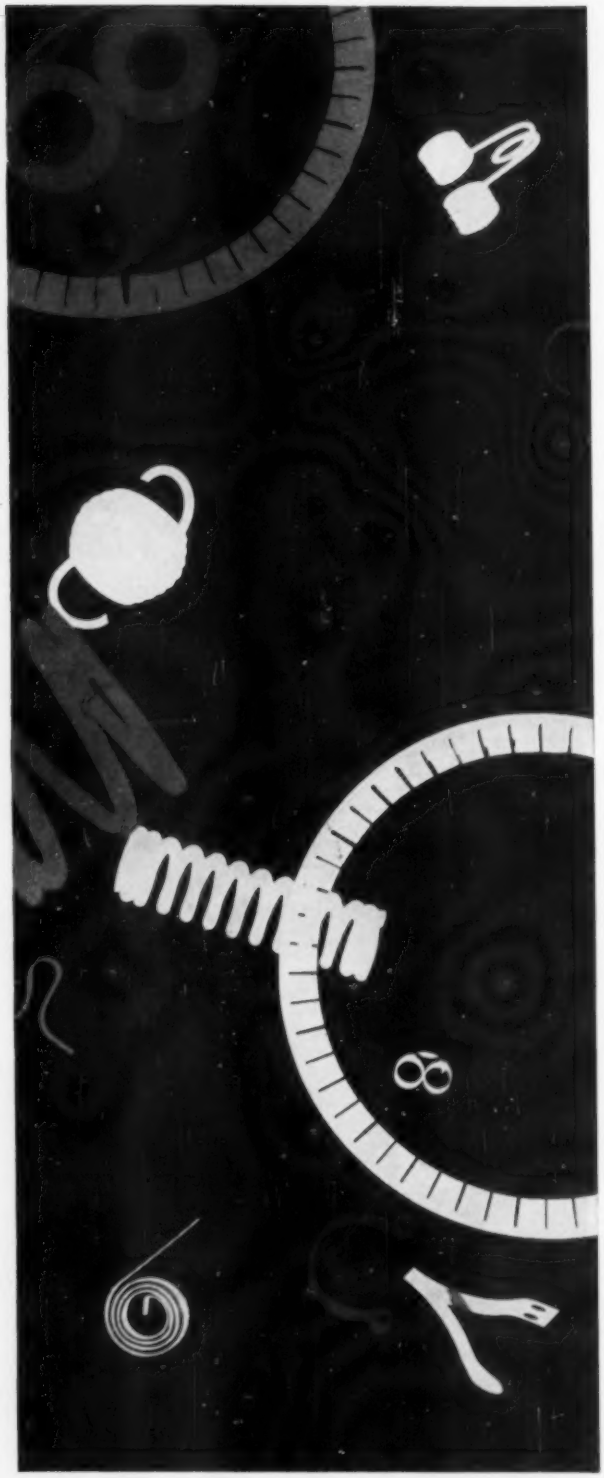

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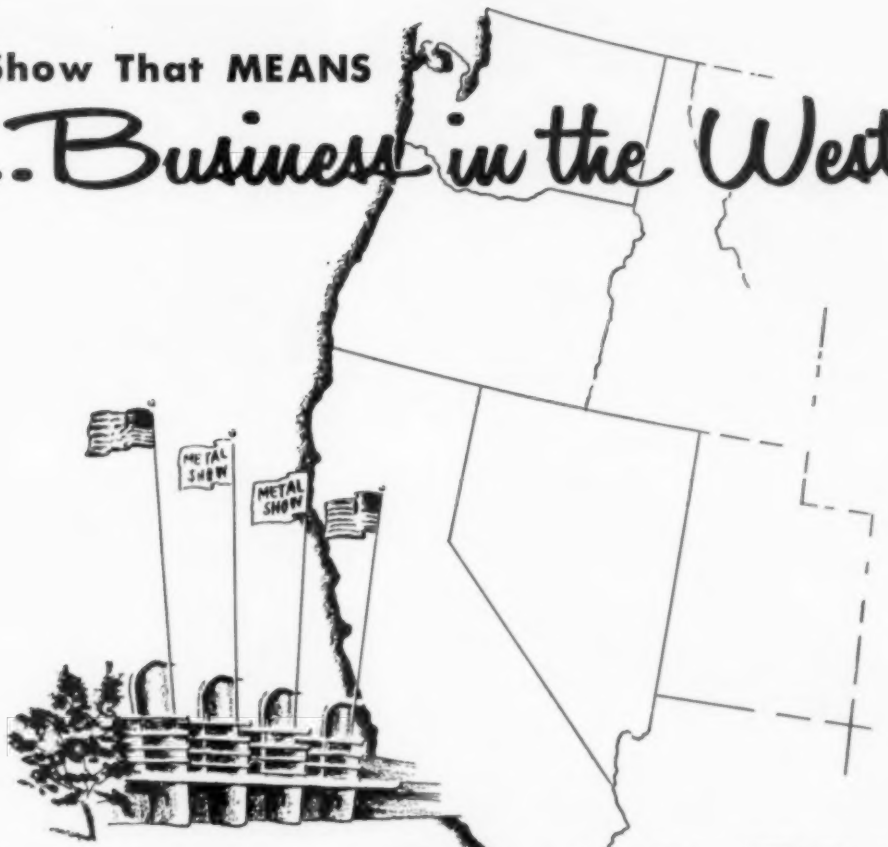

Western Metal Show

PAN-PACIFIC AUDITORIUM • LOS ANGELES

MARCH 16-20, 1959

During the past quarter-century of flourishing growth of industry in the West, one exposition pioneered and grew with this record-breaking western progress — the Western Metal Show.

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Floor plans for this 11th western show are now available. Make certain you have your copy . . . that you select your exhibit space . . . that you make your plans to exhibit in the show that will *mean business for you* in the West.

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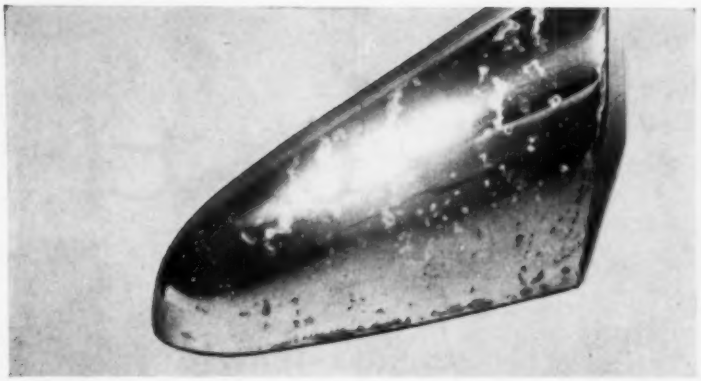
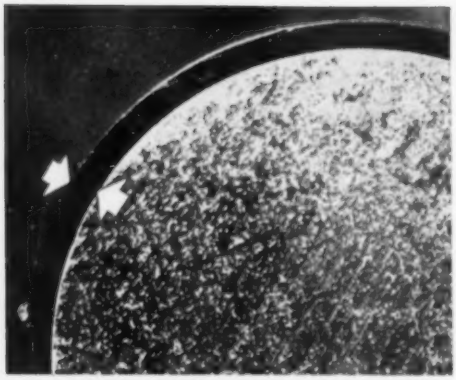
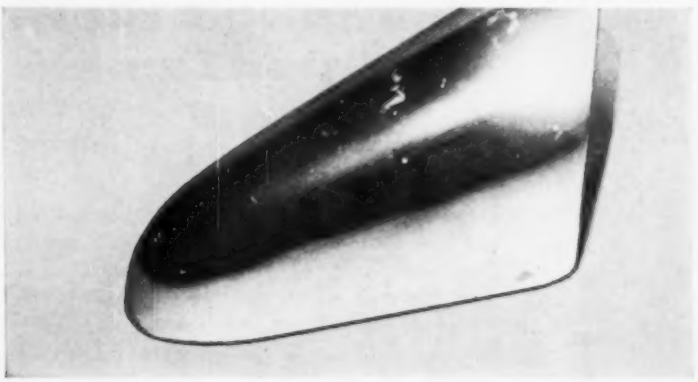
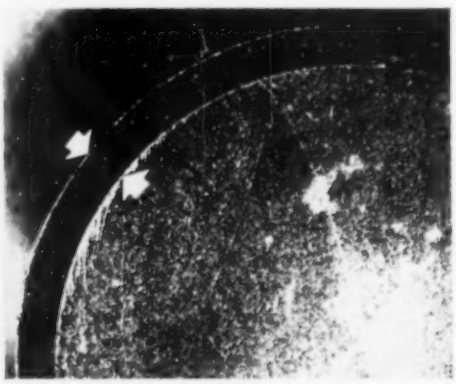


UNICHROME BRIGHT CRACK-FREE CHROMIUM MADE THIS DIFFERENCE IN PROTECTION. Photographs show results of 72 hour acetic acid salt spray test. Part at top was plated with ordinary chromium according to automotive manufacturer's specifications for copper, nickel, chromium finishing. Part at bottom had same copper and nickel deposits but Unichrome Crack-Free Chromium replaced the ordinary chromium, thus greatly increasing corrosion resistance.



UNICHROME SRHS® CHROMIUM MADE THIS DIFFERENCE IN THICKNESS. Enlarged cross sections of identical steel rods show ratio of thickness of plate from ordinary chromium solution (top) to thickness from SRHS Chromium Solution (bottom) . . . a much thicker deposit in the same plating time!





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Unichrome *Crack-Free* Chromium is far superior to ordinary chromium not only in protection, but also in operating advantages. The solution is self-regulating. It offers improved throwing power, also better coverage — even over passive nickel.

TO PLATE THICKER CHROMIUM

For those who desire thicker deposits but do not require freedom from cracking, other Unichrome self-regulating processes offer distinct advantages. They plate up to 80% faster than ordinary chromium plating processes. They cover parts with less dulling or burning, are less susceptible to clouding due to current interruption. Control is simplified by their self-regulating features.

Whichever process is best for your products, Metal & Thermit has over 30 years of service experience to help you make it work. Call in an M&T plating engineer to survey your requirements, tell you what's needed for the results you want. Or, send for Bulletins.

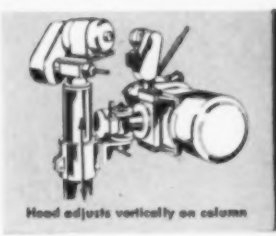
METAL & THERMIT
CORPORATION

GENERAL OFFICES: RAHWAY, NEW JERSEY
Pittsburgh • Atlanta • Detroit • E. Chicago • Los Angeles
In Canada: Metal & Thermit – United Chromium of Canada, Limited, Rexdale, Ont.

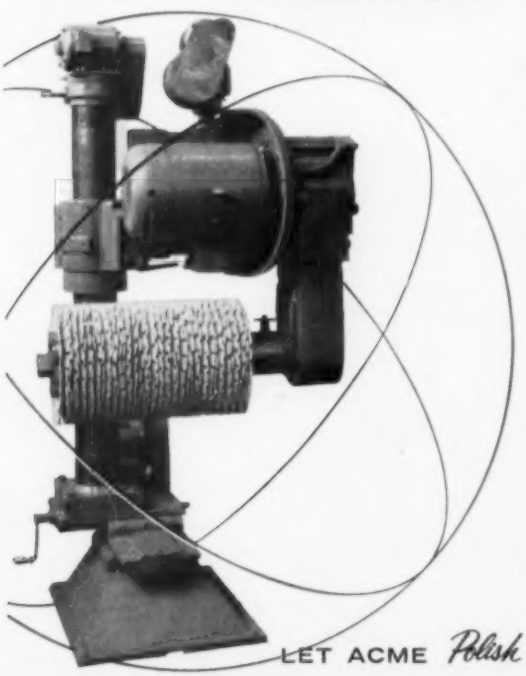
ACME G-4 KEEPS CONVERSION COSTS DOWN!

Base adjusts in 4 horizontal directions

Spindle assembly rotates 360°


Head adjusts vertically on column

Head feed is motorized



If you want machines that will set up for a fast, efficient finishing job on today's work—yet will quickly and easily adapt to next year's designs—ask an Acme engineer to show you the versatile G-4 lathe.

What does the G-4 do? Just about everything! Only four of its many adjustments are illustrated. Without the need for superstructure support, the buffing or polishing head may be faced in four directions horizontally and two vertically. It may be angled to any degree from horizontal to vertical. It may be stationary when it operates, or set for a stroking or oscillating movement. It finishes the most common or the most unusual shapes . . . reduces belt, buffing wheel and compound costs . . . and is ready for adaptation to new designs any time!

An Acme engineering specialist can help you combine these flexible basic units with automatic work-holders or fixtures to give you a set-up for low-cost, high-production finishing. Contact him to discuss your current or anticipated demands. No obligation, naturally.

LET ACME *Polish Off* YOUR FINISHING PROBLEMS

ACME MANUFACTURING COMPANY

1400 E. 9 MILE ROAD, DETROIT 20, MICHIGAN JORDAN 6-1550

LEADING PRODUCERS OF AUTOMATIC POLISHING AND BUFFING EQUIPMENT SINCE 1910

The Future of Lead...

as seen in a Crystal Ball—circa 1927

"The increased publicity given to the use of ethyl gasoline causes some to think that perhaps herein lies a new outlet of importance for lead . . . In every 1,300 gallons of ethyl gasoline there is approximately one gallon, or 14 lb., of lead tetraethyl, containing about 9 lb. of elemental lead. Present consumption of ethyl gasoline is not known, but an estimate of 750,000,000 gal. a year is sufficiently accurate for this purpose. This would represent an annual consumption of lead in the United States, for making ethyl gasoline, of approximately 2,500 tons, or one-third of 1 per cent of total domestic lead production . . . So the lead miner with an automobile cannot improve his market much by buying ethyl gas; he would do better to paint his house with pure lead paint, have nothing to do with battery eliminators for his radio set, and insist that his power be brought along the street to him in lead-incased cables."

Excerpt from an article "Lead in Ethyl Gasoline" which appeared in the October 29, 1927 issue of Engineering and Mining Journal.

But Here Are The Facts . . .

Last year some 176,000 tons of lead went into the production of tetraethyl lead. The 1927 "Forecaster" could not, of course, foresee that the discovery of tetraethyl lead would usher in a great era of automotive progress by making possible the development of ever-higher compression ratio engines and that thereby, the consumption of lead for this purpose would multiply 70 times between 1927 and 1957.

U.S. CONSUMPTION OF LEAD TETRAETHYL

1927 . . . 2,500 tons **1957 . . . 176,000 tons**

Source: American Bureau of Metal Statistics

Talking About Forecasts . . .

lead because of its density — is the most effective metal for shielding the human body from harmful radiation. Today, the amount of lead used for this purpose is relatively small. Would anyone care to predict how many tons of lead in the form of protective shielding, will be consumed in 1988?

ST. JOSEPH LEAD COMPANY **ST. JOE**

250 PARK AVENUE NEW YORK 17, N. Y.

THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

Pb-126

XXIX

This is the twenty-ninth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Cold-Finishing of Alloy Steel Bars: Grinding and Polishing

Grinding and polishing of cold-drawn or turned alloy steel bars is the concluding discussion on the subject of cold-finishing. In the processes of turning and polishing, and grinding and polishing (both of which require removal of surface metal), the surface finish of the bars, as well as their dimensional accuracy and alignment, are improved. But the ultimate in quality of bright, smooth surface finish and accuracy is produced by grinding and polishing of either cold-drawn bars or turned bars up to 4-in. diam, inclusive.

GRINDING AND POLISHING

Sizes up to and including 4-in. diam, are generally confined to centerless cylindrical grinders. Larger sizes are ground on centers. A centerless grinder includes a grinding wheel, a regulating wheel for applying pressure against the bar, and a work-rest blade which both supports the bar and guides it between the wheel spacing. Automatic feed of the whole length of the bar is accomplished because the regulating wheel is set at an angle of inclination with respect to the grinding wheel, and thus within this system the bar rotates and feeds during grinding. The bar is then polished to a mirror-like finish by passing through straightening rolls.

Both processes of turning and polishing, and grinding and polishing, are applicable to normalized, annealed, or heat-treated carbon and alloy bars. These operations do not materially affect the mechanical properties. For this reason, the end product can be machined unsymmetrically, with little or no tendency to warp.

Fundamentals Only. In the past four advertisements, we have outlined *basic fundamentals only* on the cold-drawing of alloy bars, the effect of cold-drawing, turning and polishing, and grinding and polishing.

Please keep in mind that Bethlehem metallurgists have given long study to specifications with respect to chemical composition, grain size, hardenability, machinability, and the like, of cold-drawn alloy steel bars. If you would like additional information on cold-drawn products, or alloy steels, our metallurgists will gladly give you all possible help, without cost or obligation.

When you are ready for new supplies of alloy steels, Bethlehem can offer the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in the series are now available in a handy 40-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

HOW KEY FORGING JET TURBINE TIGHT TEMPERATURE

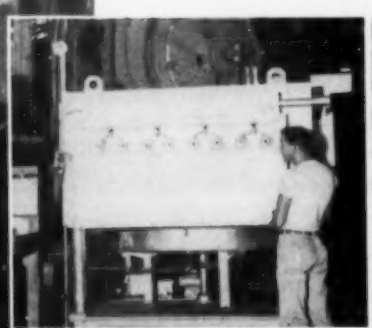
ELECTRIC FORGING FURNACES at Thompson Products, Inc. (Harrisburg plant), both General Electric and Hevi-Duty units, are equipped with GLOBAR heating elements to assure precise temperature control of alloys used for compressor and turbine vanes and blades. Shown above is one of several aisles in which both furnaces and forging presses are located.

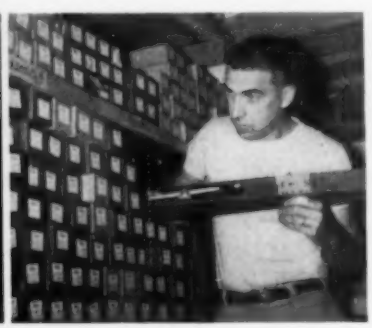
PLANT BLADES KEEPS CONTROL

Jet Division of Thompson Products, Inc. uses GLOBAR® Delta electric elements for forging and heat treating

High temperature steels for a jet's turbine blades can be critically affected by variable temperatures during heating. That's why Thompson Products, Inc.—one of the largest manufacturers of rotating and non-rotating jet engine parts in the world—uses GLOBAR Delta electric heating elements. They assure close, precise temperature control to maintain the alloy's metallurgical properties.

At its Harrisburg, Pa. plant (shown here), Thompson Products, Inc.—long noted for its advanced techniques and materials—converts bar stock to completed turbine blades. According to Mr. Robert A. Buente, Superintendent of Maintenance, "furnaces equipped with GLOBAR elements do an excellent job. If we ever go to higher production rates, we'll use more GLOBAR-type furnaces."





TERMINAL CONNECTIONS (left) for 8 GLOBAR elements are on a HEVI-DUTY furnace. Elements can be replaced without cooling the furnace or interrupting production. **STOCK OF GLOBAR** Delta silicon carbide electric heating elements (right) is kept on hand to assure fast replacement.

ECONOMIC advantages of electric heat:

There are many reasons why the use of GLOBAR Delta silicon carbide elements are economical as well as dependable, clean, safe, and quiet. There is no fire or explosion hazard, and exhaust and fuel storage facilities—and costs—are unnecessary.

Only with electric heat can heating cycles be precisely duplicated and temperatures accurately controlled, independent of the atmosphere. Product quality is improved and rejects sharply reduced. Electric furnaces and kilns are compact and space-saving. They can be located in the production line, thereby accelerating production and reducing costs per unit of product.

When evaluating heat source, remember that electric heat alone utilizes its full potential. You don't pay for waste BTU's that go up the stack. Consequently, overall operating costs are reduced, furnace maintenance held to a minimum.

Installation of Delta elements is simple, and element replacement is accomplished quickly without cooling the furnace or interfering with production.

Typical applications for GLOBAR Delta elements include furnaces and kilns for: heat treating, forging, sintering, brazing, annealing, melting, assaying, roasting, laboratory and research; ceramic firing of ferrites, titanates, steatites, glass to metal seals, electrical insulators, grinding wheels, refractories, whiteware, pottery and tile.

Find out how your operation could profit by using GLOBAR Delta silicon carbide electric heating elements. Your furnace builder can supply you with full details. The Carborundum Company, Refractories Division, Globar Plant, Dept. Niagara Falls, New York.

CARBORUNDUM

Registered Trade Mark

...you get safety, the speed you need to cool work faster than its transformation rate **here** . . . . . .

How Houghton's Complete Quenching Range Meets "S" Curve Needs To Help You Get The Exact Results You Want...

Every Time!

...you get control, to achieve the exact combination of hardness and toughness you want **here** . . . . . .

If you've ever faced a heat treating job that challenged your knowledge of quenching, you'll want to give Houghton's *complete quenching range* a long and careful looking-over. You'll find solutions here to many of the most troublesome quenching problems —varying steel analyses, eliminating quench cracks, preventing distortion, hardening to full depth, easing the shock of quenching.

These Houghton products were developed for quenching—and quenching *only*. Through them, you give yourself all the benefits of the applied knowledge and experience gained in fifty years of perfecting heat treating methods and pioneering in handling of new alloys as they were developed.

Check these product descriptions against your needs. And if you have special requirements to meet, the Houghton Man will be glad to put Houghton's full facilities for development work at your disposal. Call him, or write today to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

HOUGHTON'S COMPLETE QUENCHING RANGE

HOUGHTO-QUENCH K . . . for very fast quenching of lean alloy steels. It is ideal for greater depth of hardness where hardenability is low. The only quench faster is water.

HOUGHTO-QUENCH G...for production-line quenching. Almost as fast as Houghto-Quench K, Houghto-Quench G will deliver better than required hardness in most production-line quenching. Low drag-out, high stability. Year after year, you get the same uniform results.

HOUGHTO-QUENCH T7A...for "warm" quenching. To meet the need for a quench operating at intermediate temperatures, this high-grade oil is fortified for use up to 275°F.

MAR-TEMP OIL NO. 2...for interrupted quenching. This oil is especially formulated to resist heat-breakdown. It can be operated up to 350°F. for long periods without any deterioration.

MAR-TEMP SALT . . . for interrupted quenching. This low-melting-point salt has a working range of 350°-1000°F. It has high thermal conductivity. It eliminates distortion and quench cracks . . . improves fatigue life.

AQUA-QUENCH . . . to slow down the rate of quenching in water quenching systems. It provides safety from cracking and distortion never before possible in water quenching.

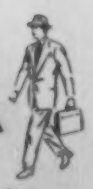
HOUGHTO-QUENCH CONCENTRATE . . . to speed up the quenching rate of oil. Added to straight mineral oil baths, Houghto-Quench Concentrate improves stability and heat-removing ability.

QUENCHING OILS

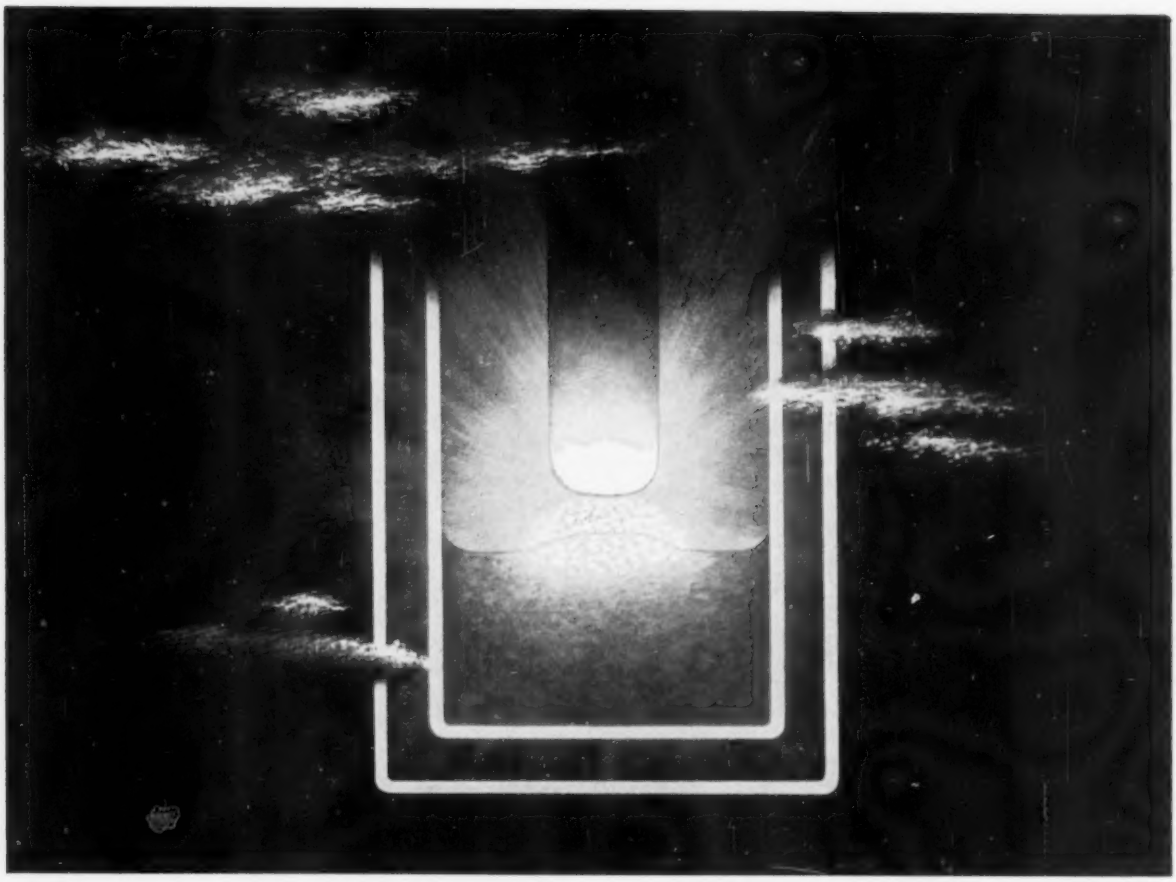
. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO



Ready to give you on-the-job service . . .



The role of Sylvania consumable electrodes in arc-cast

Metals of the Future

EXCITING and important applications await the development of new high-temperature alloys. Many of these, already in advanced stages of development, are being arc-cast from consumable electrodes.

Working hand in hand with the metal industry, Sylvania has applied its knowledge of powder metallurgy to supply the vital consumable electrode.

Special alloys as well as pure Molybdenum, Tungsten, Nickel, Copper, Chromium, Titanium, and Tantalum have been isostatically pressed and sintered in a wide range of sizes. Emphasis has been placed on "evaluation" sizes down to ½" in diameter, tailored to specific experiments.

If you're experimenting with new high-temperature metals requiring consumable electrodes, Sylvania welcomes the opportunity to work with you. Write today stating your electrode needs.

SYLVANIA

SYLVANIA ELECTRIC PRODUCTS INC.
Chemical & Metallurgical Div.
Towanda, Penna.

TUNGSTEN · MOLYBDENUM · CHEMICALS · PHOSPHORS · SEMICONDUCTORS

MEL-TROL® gives you **design insurance**

on forged high temperature parts

This turbine wheel forging will be machined down to $\frac{1}{16}$ in. thickness in some sections.

The better the forgeability, the easier and less costly the machining. But there can be no sacrifice of high temperature properties when you are depending on the strength of a minimum cross section, as this design does.

The only way to get both forgeability and uniform high temperature performance is to make sure of the uniformity and quality of the steel itself. To get a uniform forging, you have to start with a uniform billet. And a uniform billet can only come from a uniform ingot.

That's what MEL-TROL gives you.

Users of MEL-TROL high temperature alloys report they are the cleanest forging alloys of their type. Their performance in service is consistently good. It minimizes the variations in service life found in conventional alloys.

It's the result of the finest quality control tools and procedures known today used together with a new, *Carpenter*-patented mold which produces ingots with the highest uniformity yet achieved in commercial steelmaking.

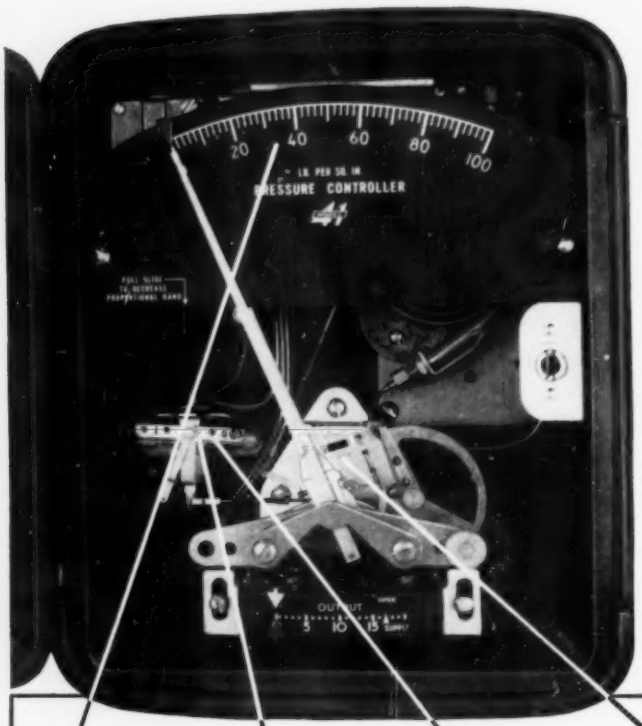
And it's easy to get this new kind of "design insurance." Just call the nearest *Carpenter* Service-Center. The Carpenter Steel Company, 133 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

Now!
An even BETTER Controller for simple processes!

...the improved Foxboro M/41A Indicating controller



Here's the Foxboro Pneumatic Controller that proved itself in thousands of successful applications throughout industry! Now, with brand new design features, it's better than ever.

The M 41A Controller offers a sharp, fast on-off action, or smooth proportional control action easily adjustable from .25% to 25%. It employs the famous Model 40 controller movement — free from backlash, lost motion, and friction. This is a rugged, low-cost, compact controller using standard M 40 parts *throughout* . . . easy to get at . . . easy to service.

For control of simple processes—temperature, pressure, liquid level, or humidity — it will pay you to investigate the convenience and the precise, reliable performance of the Foxboro M 41A Indicating Controller. Write for Bulletin 5A-13A.

New Design Features

- Longer Scale — 5" effective length.
- Snappy "On-Off" Control Action on measurement change of only ⅛ of 1% scale.
- Alternate Proportional Action adjustable from ¼ of 1% to 25%.
- "Permaligned" Precision Controller Movement — Exclusive Self-Aligning Ball-Linkage—Non-Backlash Vernier Index Drive
- Simple Rugged Construction—All Parts Easily Accessible

THE FOXBORO COMPANY, 5210 NEPONSET AVE., FOXBORO, MASS., U. S. A.

FOXBORO REG. U.S. PAT. OFF. **INDICATING CONTROLLERS**

"WEIRKOTE'S ZINC COATING STAYS SKINTIGHT. NO PEELING OR FLAKING—CAN ELIMINATE DIPPING OR PLATING AFTER FABRICATION!"

Q. Sure, but what happens on the tough jobs—like deep drawing or crimping?

A. You can work Weirkote right to the limit of the steel itself. And as I said, no peeling or flaking.

Q. Then where's the miracle? We tried galvanized before. And it struck out. Too much trouble, too much cost fixing it up after fabrication.

A. No miracle. It's just that Weirkote's made by the continuous process which integrates zinc and steel so that the toughest fabrication won't break down the bond.

Q. That means then that Weirkote can eliminate the need for plating or dipping to assure uniform corrosion protection for the most intricate part . . . is that the picture?

A. Yes, that's exactly the picture . . . and besides, Weirkote is now treated to inhibit wet storage (white oxide) stain.

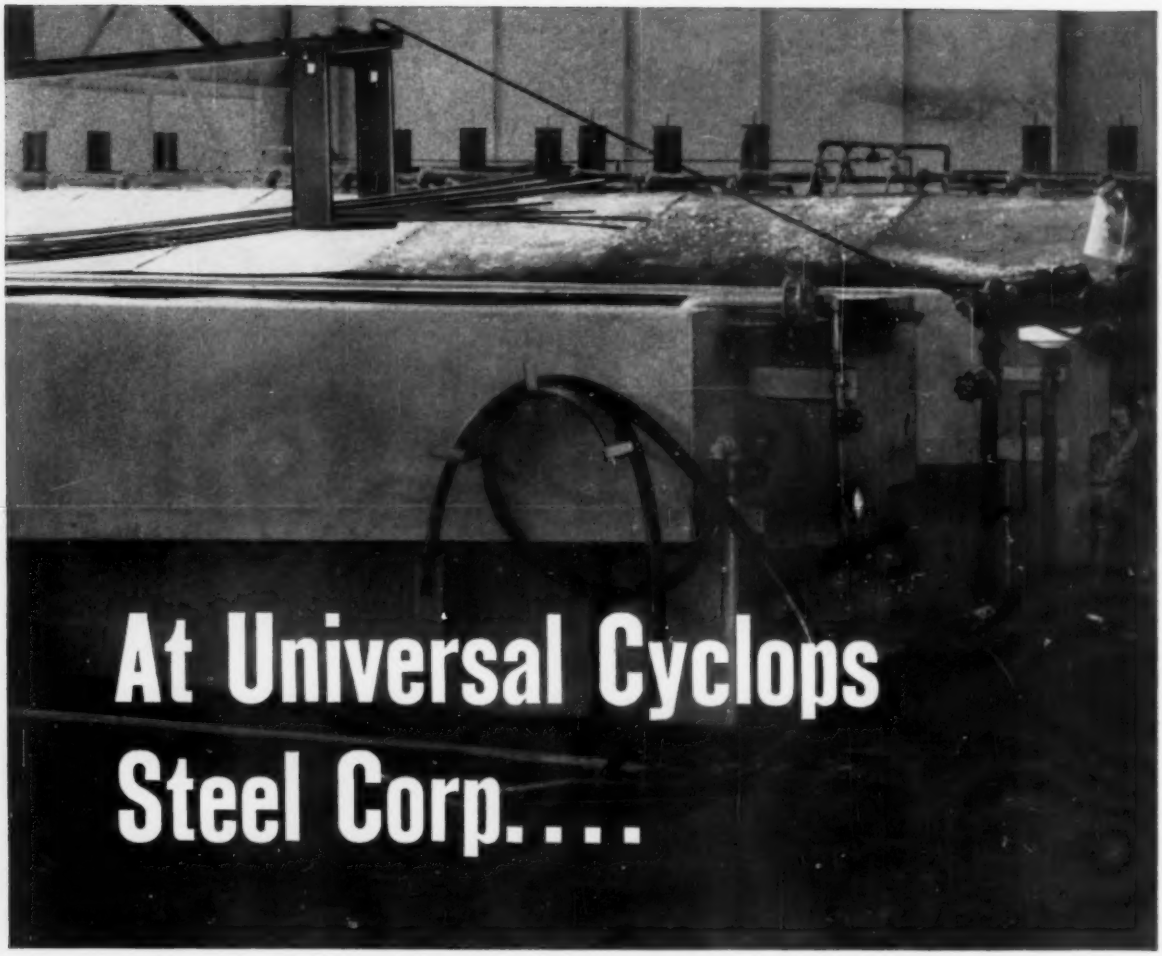
Send today for free booklet that details the time- and cost-saving advantages of using skintight zinc-coated Weirkote. Write Weirton Steel Company, Dept. S-8, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION



At Universal Cyclops Steel Corp....

A third Du Pont Sodium Hydride unit efficiently descales bar products without pitting or etching

After several years of success with two Du Pont Sodium Hydride units at their Bridgeville, Pa., plant, Universal Cyclops is now operating a new unit in Titusville, Pa. Here they are completely descaling hard-to-clean stainless- and tool-steel bars in 20 minutes or less.

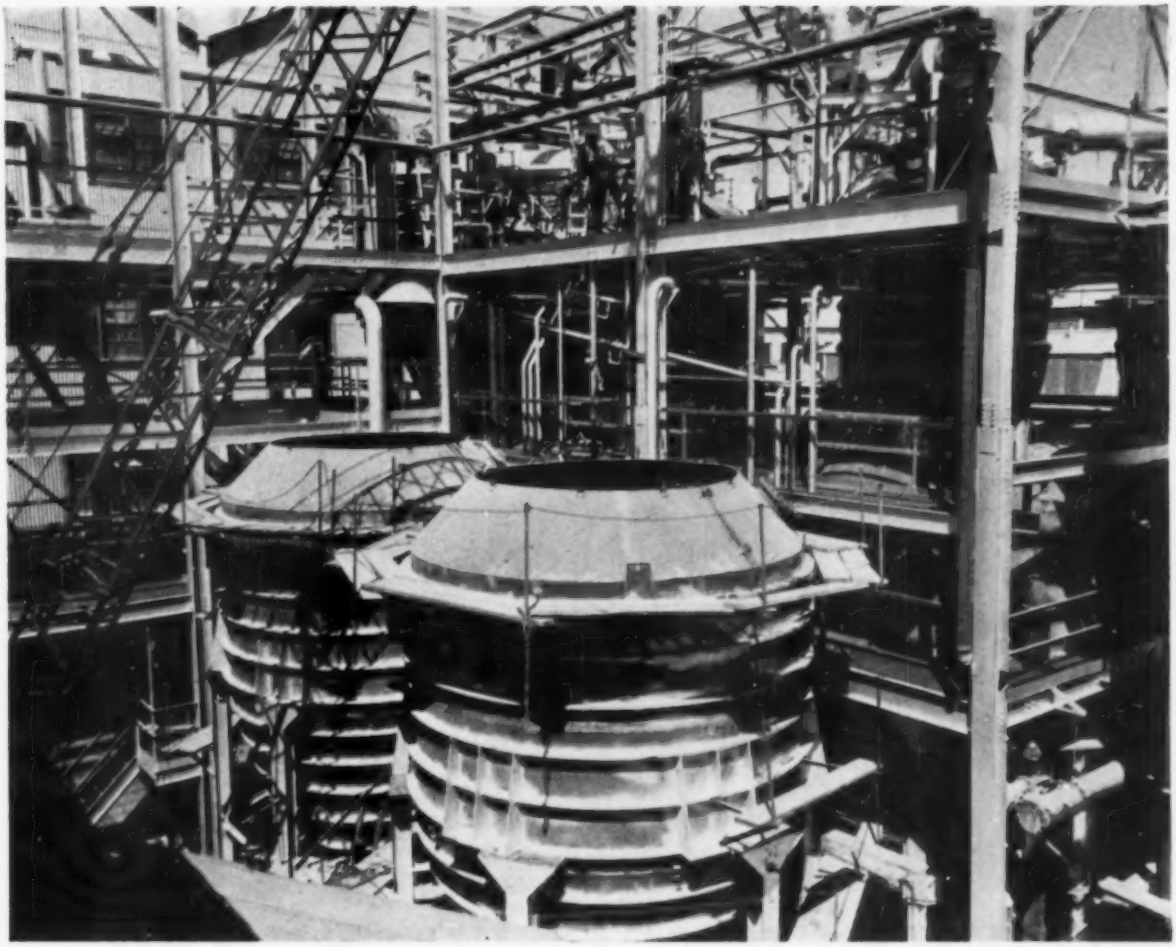
Du Pont's Sodium Hydride Process can give you ideal descaling results: *a lustrous pearly-gray finish with no etching or pitting!*

Any metal unaffected by fused caustic at 700°F. can be quickly descaled by the Du Pont Process, and there's never any loss of gauge. Costwise: substantial savings in acids and waste disposal. We'll be glad to give you all the facts on the Du Pont Sodium Hydride Process. Just drop us a line at the address below.

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

ELECTROCHEMICALS DEPARTMENT
Sodium Products Division

E. I. DU PONT DE NEMOURS & CO. (INC.)
Wilmington 98, Delaware



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-corrosion cracking after a year.

No stress-relieving here —no stress-corrosion cracking!

Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

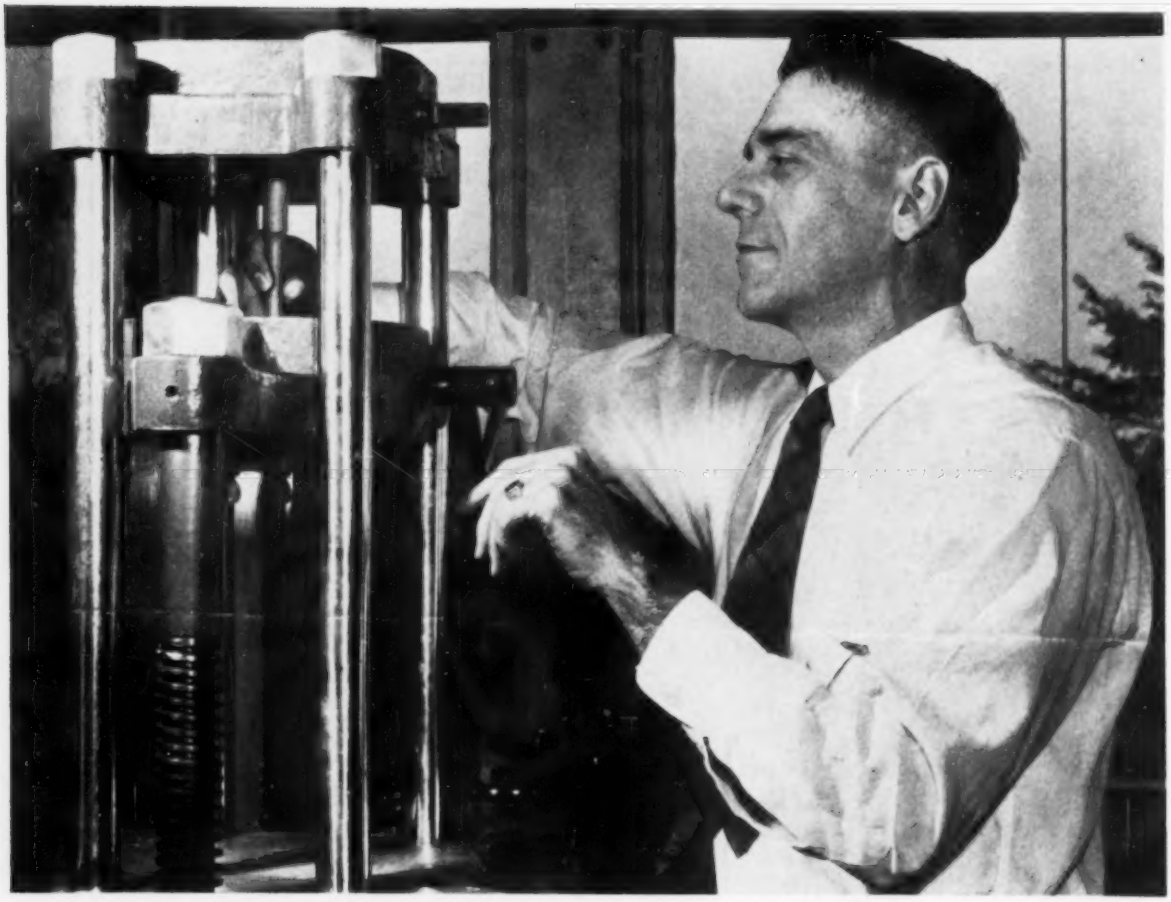
At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion cracking.

New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 21J, Milwaukee 46, Wis. West Coast plant: Burbank, Calif. — Southwest plant: Garland (Dallas County), Texas.*

TS-6

AMPCO®



WHY IS JOHN HOFFER NOW A BETTER "METALS MAN"... WHY IS HE MORE VITAL TO THE METALS INDUSTRY?

Elements of Metallurgy
Heat Treatment of Steel
High Temperature Metals
Titanium
Metals for Nuclear Power
Stainless Steels
Electroplating and Metal Finishing
Gray Iron Foundry Practice
Oxy-Acetylene Welding
Steel Foundry Practice
Primary and Secondary Recovery of Lead and Zinc
Steel Plant Processes
Copper, Brass and Bronze
Magnesium
Tool Steels
Arc Welding
Blast Furnace Operations

He used his spare time to complete an MEI home study course. . . . and became an even better "metals man".

Mr. Hoffer has been an Eastman Kodak metallurgist for 16 years. His work involves the specification and metallurgical inspection of materials. With 16 years' experience, many men would have the "know it all" attitude. Not Mr. Hoffer.

He inquired about ASM's home study division, the Metals Engineering Institute. After receiving descriptive information, he enrolled in the "High Temperature Metals" course. He took it at home, in his spare time, and completed it with an average grade of 91%. Now he knows more about metals. That's why he is a better "metals man" now . . . and more vital to the metal industry.

Mr. Hoffer thinks highly of MEI courses. In fact, he will be the instructor when the Rochester Chapter of ASM gives MEI's "Heat Treatment of Steel" course to many of its members.

To increase and up-date your knowledge of metals, look into the home study courses offered by MEI . . . a division of your own American Society for Metals. A new, 32-page illustrated catalog has just been prepared which gives an attractive review of all MEI courses and an introduction to the MEI staff and authors.

MEI will send you a copy of "Training Courses for the Metal Industry" with absolutely no obligation on your part . . . just return the coupon below.

METALS ENGINEERING INSTITUTE

A DIVISION OF AMERICAN SOCIETY FOR METALS
7301 EUCLID AVENUE: DEPT. P108 • CLEVELAND 3, OHIO

Please send me your 32-page catalog:

"Training Courses for the Metals Industry"

Name_____

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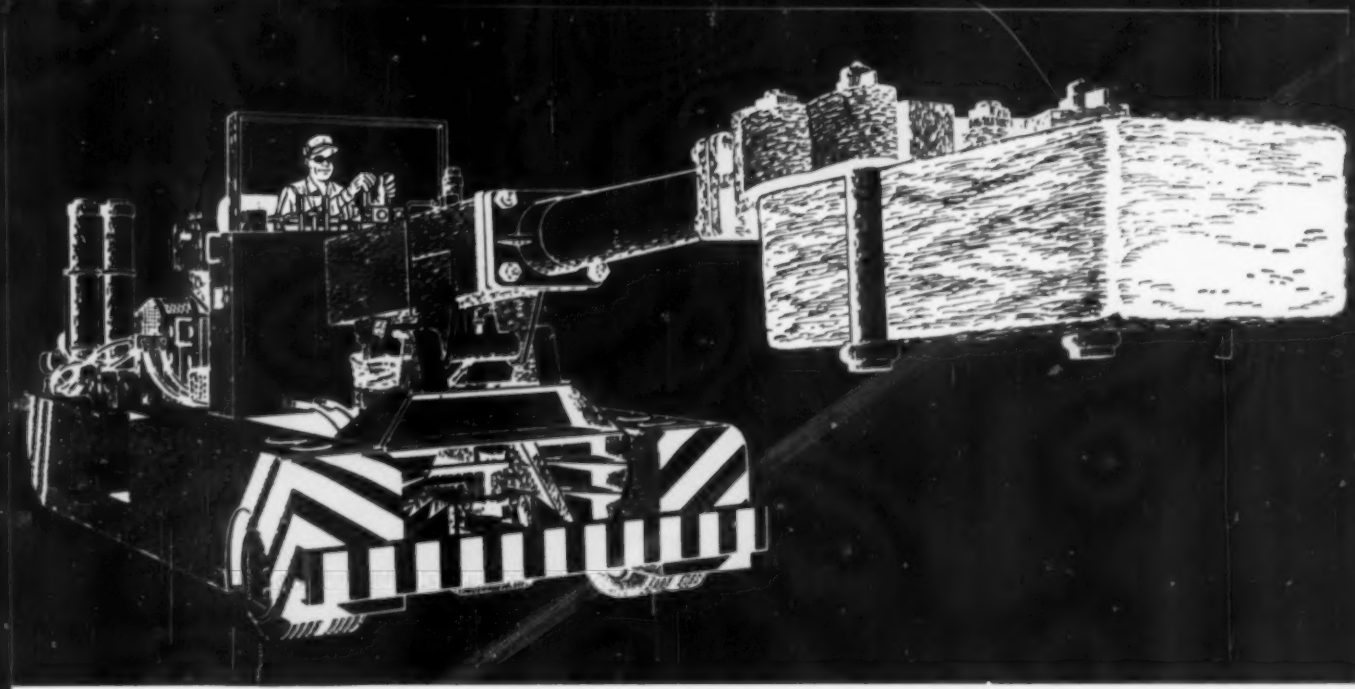
City_____ Zone_____ State_____

Company_____



You save time, space and money with this Salem-Brosius furnace charging machine

For maximum efficiency and flexibility in furnace operations, load and unload your heating furnaces and charge your melting furnaces with a Salem-Brosius Auto-Floor Charging Machine. One man at the controls operates this agile piece of equipment, serving furnaces faster and with greater all-around economy than is possible with any other stock-handling equipment.

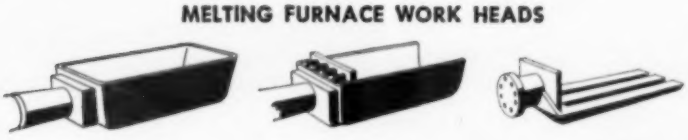
Floor travel is rapid and unencumbered, and stock handling is swift, positive and effortless. It reduces manpower by mechanizing furnace charging.

Self-powered, the machine is built in seven sizes, ranging in load carrying capacities from 2000 to 20,000 lb., and operates at floor speeds up to 250 ft. per min., doing the complete stock-handling job without auxiliary materials handling equipment. It requires no floor installations that become permanent obstructions; nor does it become an obstruction when not in use, because it can be parked out of the way. The Salem-Brosius Charging Machine is highly maneuverable, being able to turn on its own wheelbase to reach furnaces and stock piles anywhere in the plant.

Initial cost of the Salem-Brosius Charging Machine is far less than other types of charging equipment. It has saved as much as 75% in operational costs, replacing several men of a furnace crew. It eliminates costly maintenance of elaborate materials handling equipment, while requiring a minimum of maintenance itself.

Before you invest in expensive stock-handling equipment, investigate the Salem-Brosius Auto-Floor Charging Machine—designed and built by men who know your stock-handling problems.

MELTING FURNACE WORK HEADS



Rotating Box | Pusher Box | Pusher Fork

HEATING FURNACE WORK HEADS

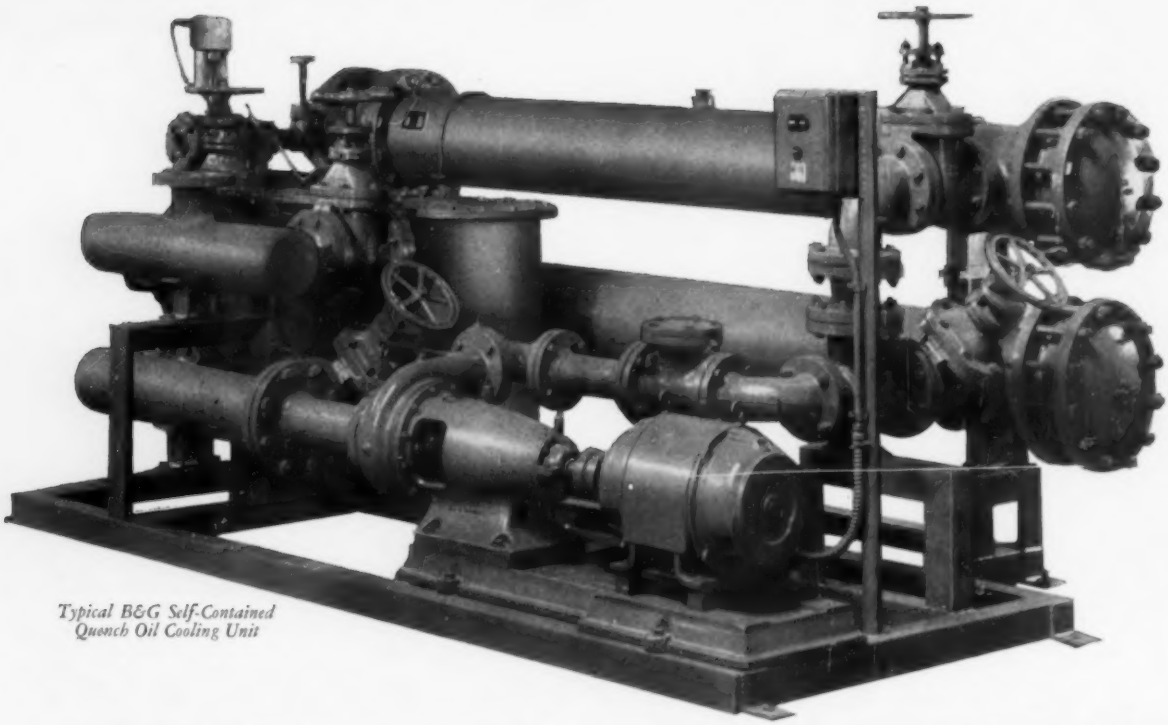
Tongs | Sliding Jaw

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

In Canada: Salem Engineering Limited • 1525 Bloor Street West, Toronto 9, Ontario

SPECIAL MECHANICAL EQUIPMENT • INDUSTRIAL HEATING FURNACES • MATERIALS HANDLING EQUIPMENT



Typical B&G Self-Contained Quench Oil Cooling Unit

Complete in every detail for

Controlled

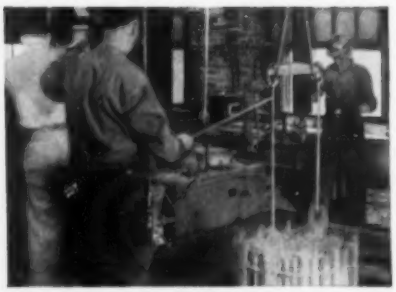
QUENCH OIL COOLING

Proper control of quench oil temperature is the certain way to maintain uniform quality in heat-treated metals and to avoid excessive sub-standard rejects. The only question is how to provide that control in the most practical, efficient manner.

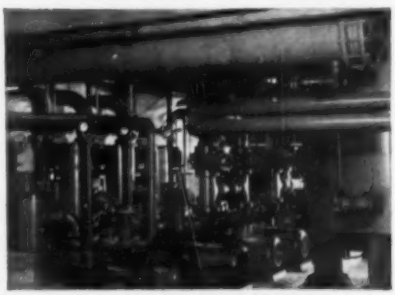
While the individual components of an oil cooling installation can be purchased and assembled on the job, the trend today is to install completely factory-assembled oil cooling systems.

To meet this demand, B&G offers completely self-contained oil cooling units—integrated in every respect—ready for immediate operation. These units are engineered to your specific requirements.

Whether your heat treating volume is large or small, the services of the B&G engineering department are available. Your request for information will receive prompt attention.



Every piece uniform in quality because uniformly quenched



Battery of B&G Quench Oil Coolers

B&G QUENCH TANKS

Properly designed to induce maximum turbulence in the quench oil. B&G Quench Tanks are available in standard models or can be built to meet any specific quenching requirement.

●

Send for this combined Catalog and simplified Selection Manual for B&G Self-Contained Quench Oil Coolers

*Hydro-Flo**

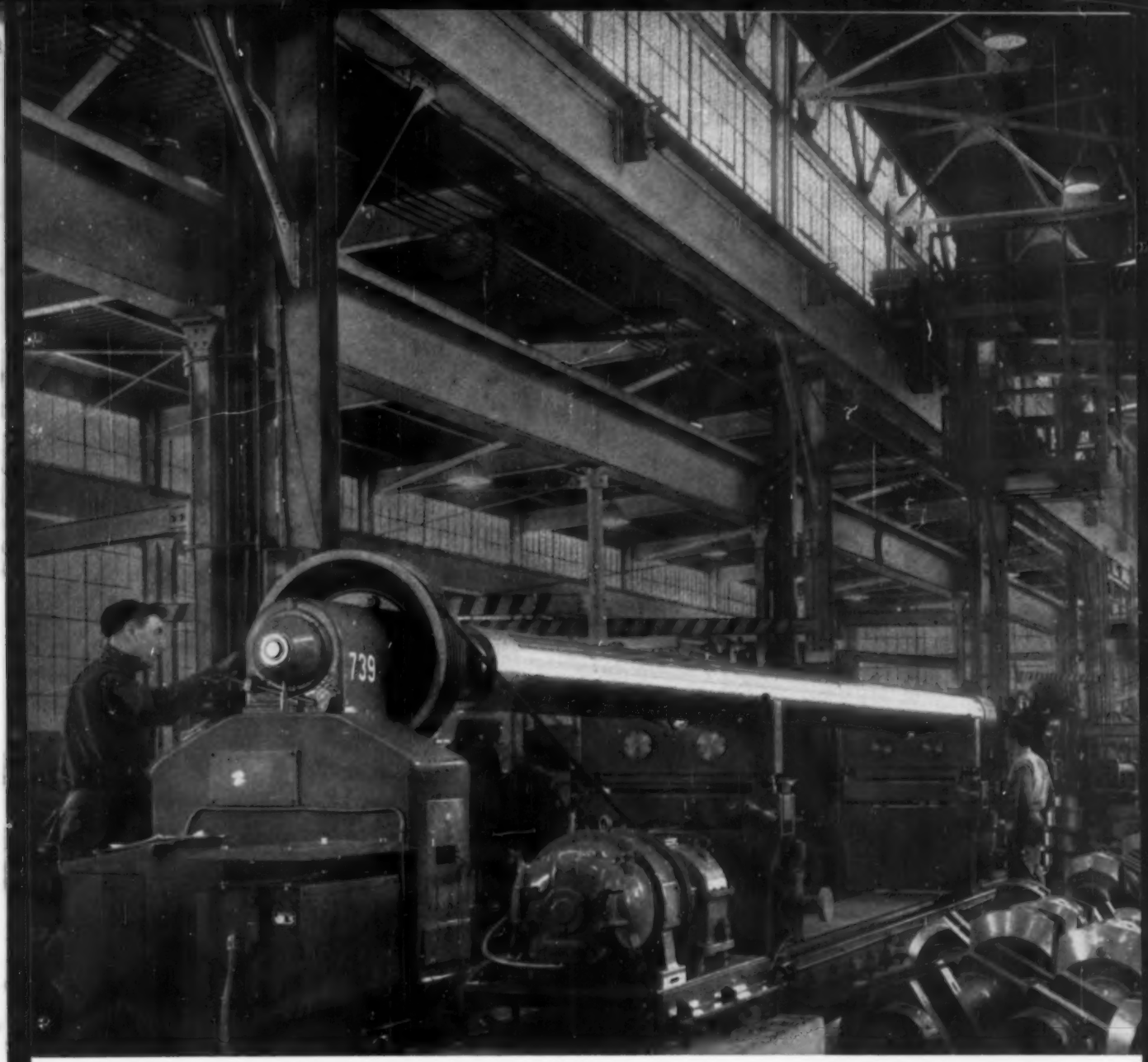
OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. FL-16, Morton Grove, Illinois

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, W. Toronto.

*Reg. U.S. Pat. Off.



WHO FORGES THE TOUGH ONES?
and dynamic balances them, too?

To further National Forge's reputation for producing precise forgings, we've installed one of the largest, most accurate dynamic balancing machines in use. Our American-Trebel has a 33,000-pound, 60-foot capacity.

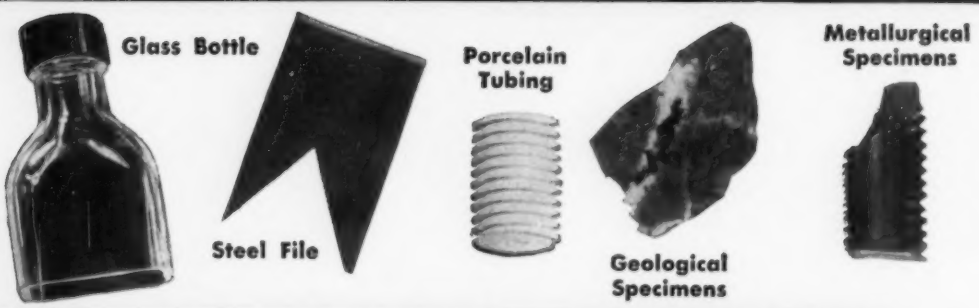
Pictured on the machine is a 42 ft. propeller shaft that has been forged, machined, and hollow bored—all operations done in our National Forge plant. NFO specialists are shown balancing this 15,500 lb. shaft.

If you want one responsible source to produce and control the quality of your forgings . . . from melting and forging the steel through machining and dynamic balancing . . . call National Forge. Let us quote on your next job—and *prove* "who forges and dynamic balances the tough ones . . . best!"

NATIONAL FORGE & ORDNANCE COMPANY
IRVINE, WARREN COUNTY, PA.

SEE US AT THE METALS SHOW, BOOTH 2410

Intricate Cutting Operations Accomplished Quickly and Perfectly



CUTTING-OFF MACHINE

Cuts Metals, Glass, Stone, Quartz, Plastics

Cuts flat materials or cylinders up to 3 inches in depths or diameter.

Special Features Include Miter Gage

MITER GAGE—Cuts of any angle can be made by a simple manipulation of this gage. Its large, convenient scale provides accurate settings.

FOOT-OPERATED ELECTRIC SWITCH — Connected to current by means of BX cable.

WATER PUMP — Fitted with individual motor drive and replaceable impeller. Pumps water from the sump to the cutting wheel.

SPRAY HEADS—Play steady stream of water on the cutting wheel to keep it cool. The water then returns to the sump.

ADJUSTABLE STOP — Used for cutting pieces to exact duplicate lengths.

Write for **BULLETIN 2237—J**

Cat. No. 5-2416, Cutting-Off Machine, 115 volt, 60 cycle, single phase, 1½ h.p. motor, size 25 x 25 x 48 in. high....**$673**

Other models available for 230 and 440 volts.

AMINCO

AMERICAN INSTRUMENT COMPANY, INC.

Silver Spring, Maryland

In Metropolitan Washington, D. C.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Wind shields for 120-mm shells die-cast with Cromo-High V tool steel

Each piece has to be virtually perfect when you're die-casting aluminum wind shields for 120-mm shells. Tooling up for a job like this calls for a hot-work steel that will turn out high-quality castings and at the same time keep production costs low.

Bethlehem has several grades of hot-work tool steel which could be considered for such a highly specialized application.

The die caster weighed all the facts with Bethlehem's local tool steel distributor. Together, they came up with an excellent tool steel for jobs of this sort—Cromo-High V.

Cromo-High V is our 5 pct chrome-moly hot-work tool steel, containing 1 pct vanadium. A grade that has proved its stubborn resistance to wash and erosion, it also has the stamina for long runs.

Cromo-High V is uniformly annealed for easy machining. It has good center density and grain refinement, and is free from porosity. And there's little chance of cleavage cracking when adequate radii are used in the die, and the steel is properly heat treated.

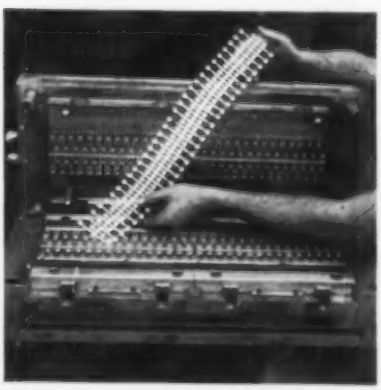
A trial run with Cromo-High V is the best way to learn how good a tool steel it really is. Your local Bethlehem tool steel distributor either has it in stock, or can get it delivered to you quickly.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Air-quenching means longer service life for hot-work tools

Most hot-work tool steels can be hardened by quenching in oil or air. Because of convenience in handling, and to avoid excessive scale, it is often preferable to quench some hot-work tools in oil. However, air-quenching is considered better practice, for it produces lower residual stresses than when tools are liquid-quenched. Since heat-check failures develop from surface stresses which are produced in service, the presence of residual stresses in the tool can lead to premature failure.

Tools having low residual stresses are best suited for long service on hot-work applications. That's why air-quenching is usually best for hot-work tools.



Plastic Beads Molded with Duramold B

Here is an injection mold, with 120 cavities, used by R. A. Koegl Stamp & Die Works, Inc., Hillside, N. J., to produce Plastic Poppit Beads. The steel was supplied by Ackerlind Steel Co., Inc., N. Y. Duramold B is our oil-hardening chromium type of plastic-molding die steel, containing an addition of boron. Its annealed hardness of 100 max Brinell assures ease in cold-hobbing and its alloy content gives it high core strength.

Greater Heat-Treating

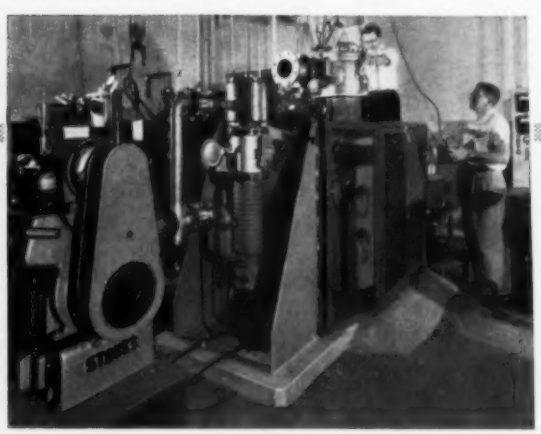
with Stokes Vacuum

Heat-treating processes have taken forward steps and gained new momentum through the advances of vacuum furnace technology. These are but a few examples of industries who now rely on Stokes systems to meet their specific production requirements.

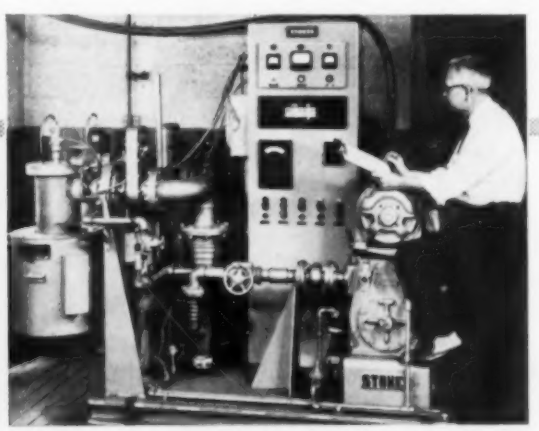
Stokes' extensive design experience and manufacturing facilities combine to make possible these new vacuum heat-treating opportunities. You have a choice of a complete range of types and sizes of furnaces. The systems are offered complete – placing in Stokes a single-source responsibility for performance and reliability.

Stokes offers additional advantages that can contribute to your successful metallurgical programs. Stokes can, for example, deliver a complete turn-key installation – erected, tested and delivered "in operation". Systems also benefit from the use of stock components – facilitating faster delivery. Stokes systems are furnished to do the best possible job at lowest cost to you.

Standard Stokes Vacuum Heat-Treating Furnaces are available for experimental and as full



At The Budd Company's Defense Division, metal components are designed and produced for important and classified nuclear reactor work. Because of the characteristics of the metals used, new procedures were necessary for welding, heat treating and pickling. The Stokes Vacuum Furnace has assumed an important role in these vital processes.



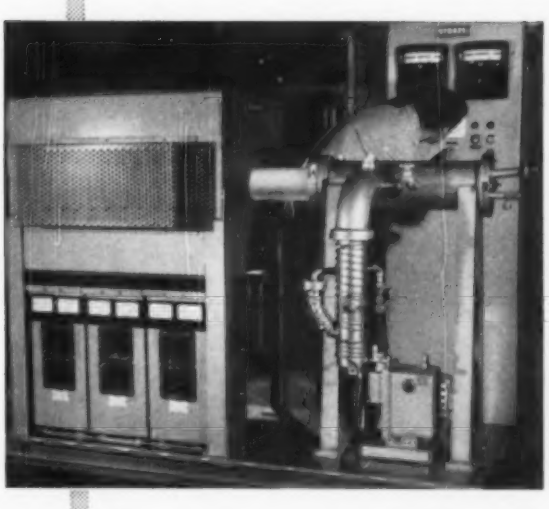
At Associated Spring Corp., Bristol, Connecticut, precision springs finer than a human hair are vacuum heat treated to rigid specifications. Of critical alloys, they require high temperatures. If treated in atmosphere, surface oxidation would be intolerable. A Stokes Vacuum Furnace enables production of springs for even the most delicate instruments.

Progress...

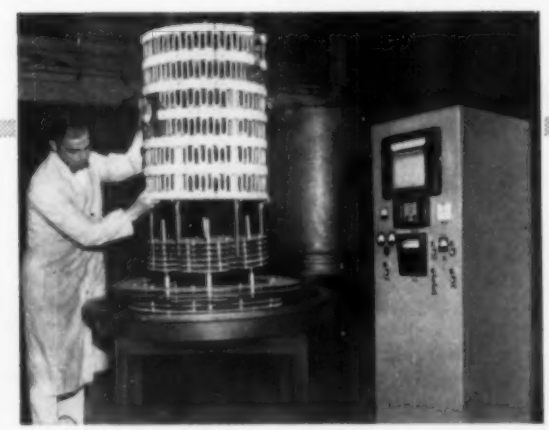
Furnaces

production size systems. Other types are available for melting, refining, casting, sintering, brazing and stream degassing. Special systems can be designed to meet the exact needs of specific operations. All-the-way service, before and after the sale, completes the picture of how well Stokes is equipped to work with you.

You can take full advantage of Stokes' advanced vacuum technology. The Stokes Engineering Advisory Service will assist you in planning and designing a heat treating installation that will best serve your exact requirements. Call Stokes—today.



A resistance-heated, two-zone, high temperature Vacuum Heat-Treat Furnace . . . installed for operation over 2500°F. Available in sizes to 9" I.D., for brazing, out-gassing and heat-treating . . . in both research investigations and small parts production.

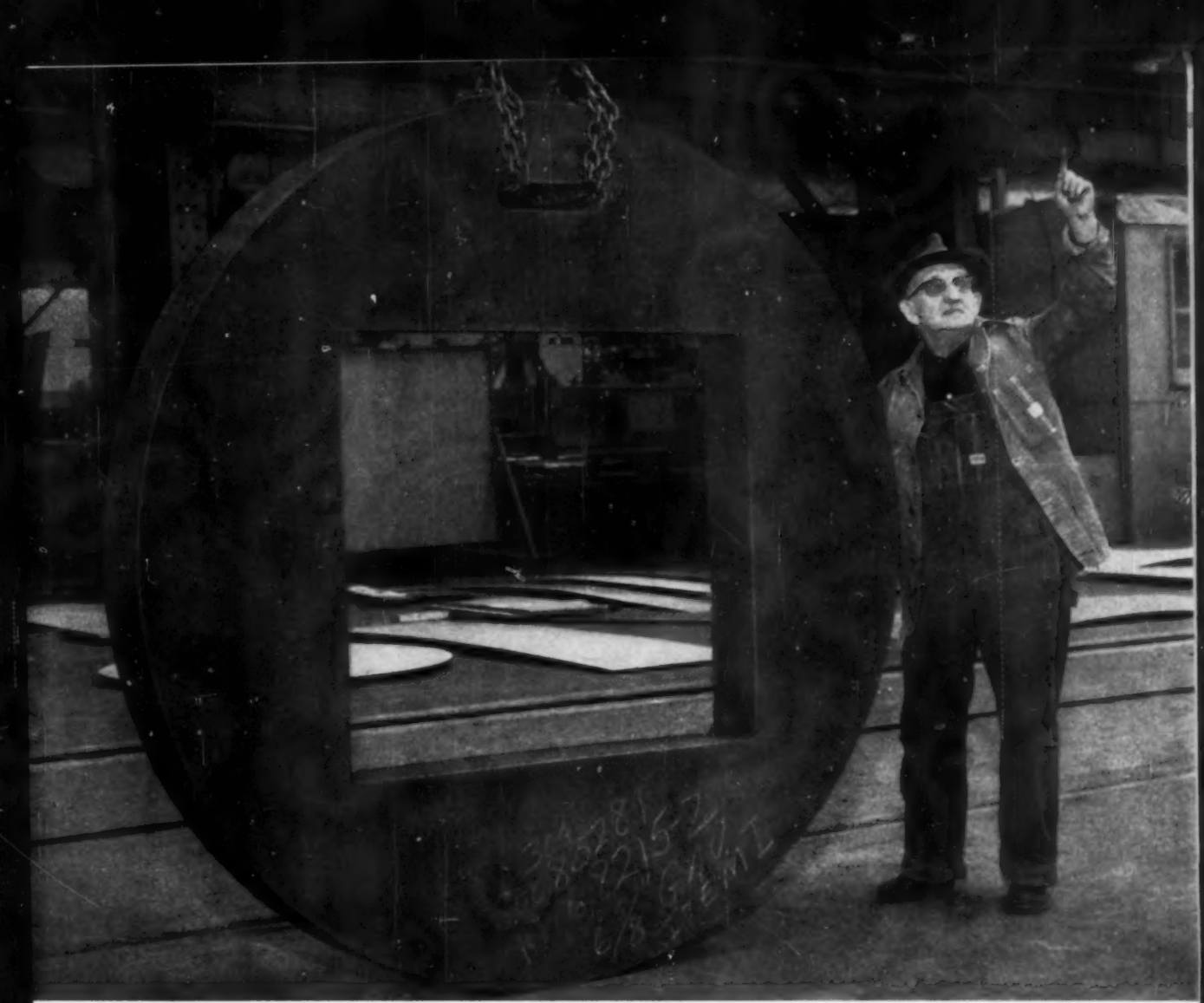


A cold wall furnace capable of providing high temperatures at unusually low pressures is one of the most recent developments of Stokes. It is particularly applicable to high temperature solid state processing. Depending on the nature of the application, temperatures up to 2000°C are attainable at sub-micron pressure. Customer built for specific requirements, these furnaces are offered in a wide range of sizes, for research or production service.

In addition, Stokes offers complete laboratory facilities and technical assistance for investigation of commercial heat treating applications where highest temperatures are necessary.

Vacuum Equipment Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES



Type 304 stainless plate, dimensions: 6⅛" thick x 75" diameter. Weight, 8655 lbs.

take a look

...at the clean edges of this stainless plate accurately cut by Carlson

THIS stainless plate illustrates something that's almost a Carlson exclusive. Few producers can make plates of such heavy gauge, and fewer still have the long experience in flame cutting stainless to precise dimensions. To develop the proper equipment, the exact gas and iron powder formula, and the special nozzles, took Carlson engineers years of effort. But the result was worth it.

The edges achieved by these improvements reduce the cost of subsequent machining operations. And every Carlson stainless plate—whether heavy or light gauge—carries its own identification. Its chemical and physical properties are known and recorded. Its dependable performance on the job is assured.

The complete reliability of every Carlson service will materially reduce your ultimate costs. Our specialists make certain that your instructions are followed in every detail. Write, wire or phone for further information on all our services in stainless steel.

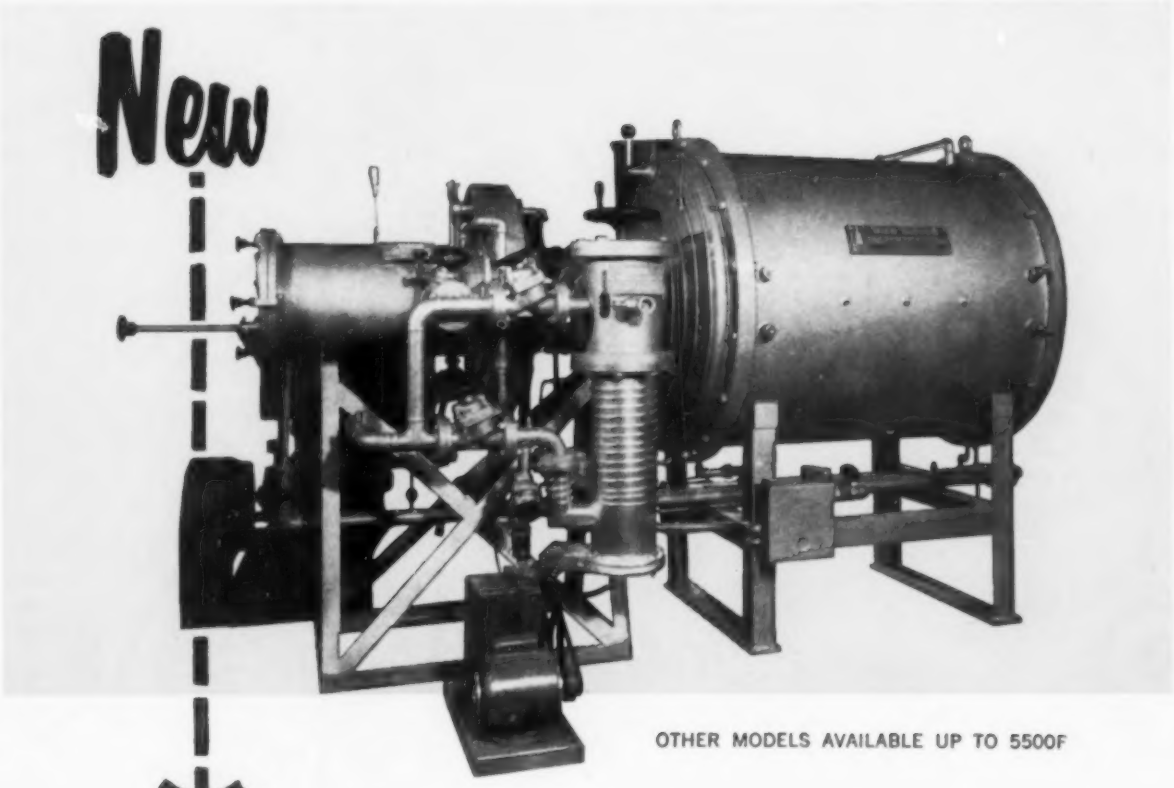
G.O.CARLSON *Inc.*

Stainless Steels Exclusively

128 Marshalton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS AND SHEETS (No. 1 Finish)

New



OTHER MODELS AVAILABLE UP TO 5500F

3000F INTERNALLY-HEATED PRODUCTION FURNACE

Setting the pace! Leading the field! Yes, HVEC's new internally-heated high temperature resistance vacuum furnace represents the most advanced state of the art. Here are the reasons . . .

Designed specifically for brazing, heat-treating, and sintering, this furnace is capable of operating continuously at 3000F at a vacuum of 5×10^{-5}mm Hg. The dual zone Molybdenum cage-type elements and the five-layer moly and stainless steel heat shields permit extremely rapid heating and cooling rates.

HIGH VACUUM EQUIPMENT CORPORATION produces a complete range of internally-heated furnaces, from the laboratory model to the largest production unit. Furnaces are available with either molybdenum, tantalum, tungsten or graphite elements ranging to 5500F.

If you are investigating high or ultra-high temperature furnaces, standard or custom designed, why not write or wire to HVEC, the established leader in the field.

See our Booth No. 408

HIGH VACUUM EQUIPMENT CORPORATION manufactures a complete line of standard vacuum metallizing units; induction, resistance, and arc furnaces; pumping systems and related components.

HIGH VACUUM EQUIPMENT CORPORATION

HINGHAM • MASSACHUSETTS

HI-VAC

OHIO STEEL FOUNDRY CUTS COSTS MORE THAN 50% WITH NUCLEAR SYSTEMS' RADIOGRAPHY MACHINES

Art Gross, chief metallurgist of Ohio Steel Foundry Co., Springfield, Ohio, states that by using two radiography machines designed and manufactured by Nuclear Systems, a division of The Budd Company, approximately 3000 "shots" a month are made in testing castings of various sizes and shapes.

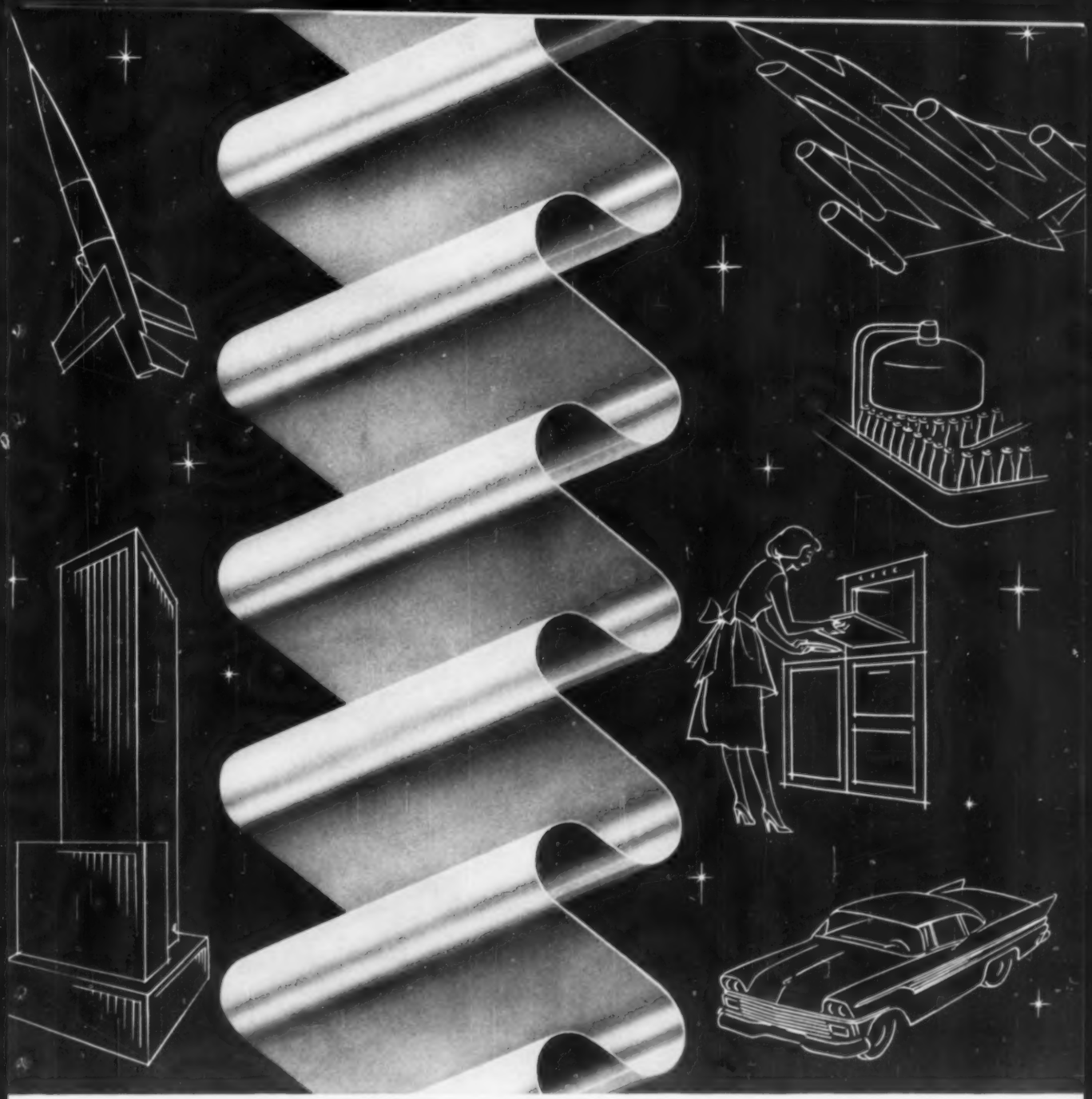
"By exposing a number of castings at one time," said Mr. Gross, "Ohio Steel has cut operating costs to less than half of what we'd spend if we used X-ray equipment. Also, if we used X-ray, we'd require 50% more people on the job to maintain safety from exposure.

"Using Nuclear Systems' models 10 (shown above) and 50, we keep the machines in use 24 hours a day checking production fittings such as valves, elbows and tees. To control quality we radiograph about 10% of this type equipment."

Nuclear Systems manufactures a complete line of gamma radiography machines for all industrial requirements. Offices in Philadelphia, Chicago, San Francisco and Los Angeles. Sales representatives in principal cities. Catalog on request.

Visit our booth at the National Metal Exposition, Cleveland, Oct. 27-31.

NUCLEAR SYSTEMS
A DIVISION OF THE BUDD COMPANY Philadelphia 32
Budd



J&L STAINLESS STEEL

The Solution for Many Basic Engineering Problems

Product designers, industrial designers, and engineers find stainless steel provides advantages no other commercial metal can offer. Its ability to fabricate readily into design, its high tensile strength, its resistance to distortion under extreme hot or cold applications, plus its corrosion-free properties, gives stainless steel a distinct advantage over other basic metals.

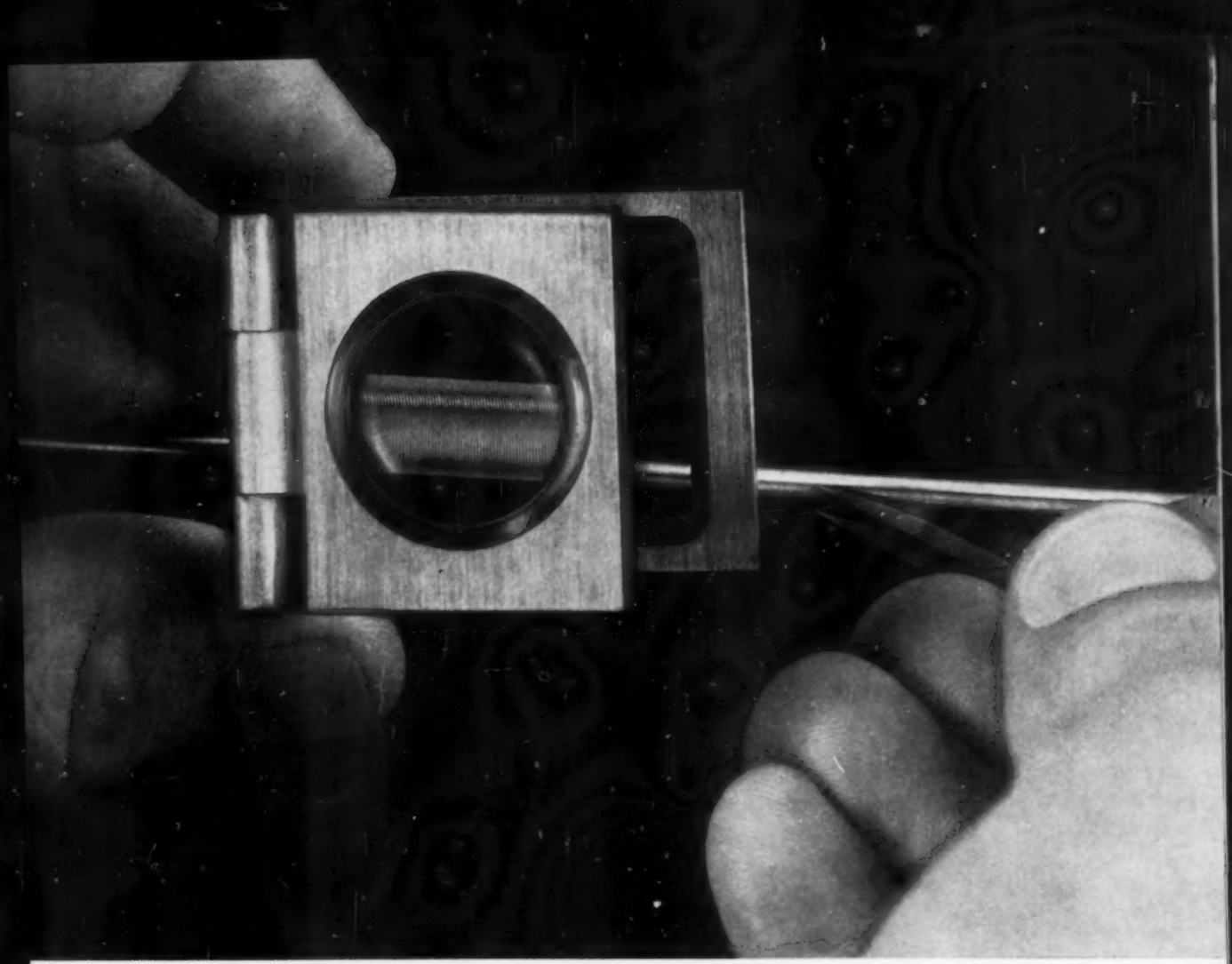
J & L offers a wide selection of quality stainless sheet and strip to extremely close tolerances up to widths of 48". Write for these technical data:

1. Laboratory Corrosion Data.
2. Data Sheets (please specify the grades in which you are interested).

VISIT OUR BOOTH NO. 36
AT THE METAL SHOW
OCTOBER 27 THROUGH 31
CLEVELAND, OHIO

Improve your Products with . . .
J&L STEEL STAINLESS
BAR • WIRE • SHEET • STRIP

Jones & Laughlin Steel Corporation • **STAINLESS and STRIP DIVISION** • **Box 4606, Detroit 34**



How "high fidelity" in music spring wire licks a big production problem

Leading producers of carbon paper apply the carbon coating by means of steel rods closely wound with hair-fine music wire. The wire-to-wire valleys, as determined by wire diameter, control the amount of carbon deposited.

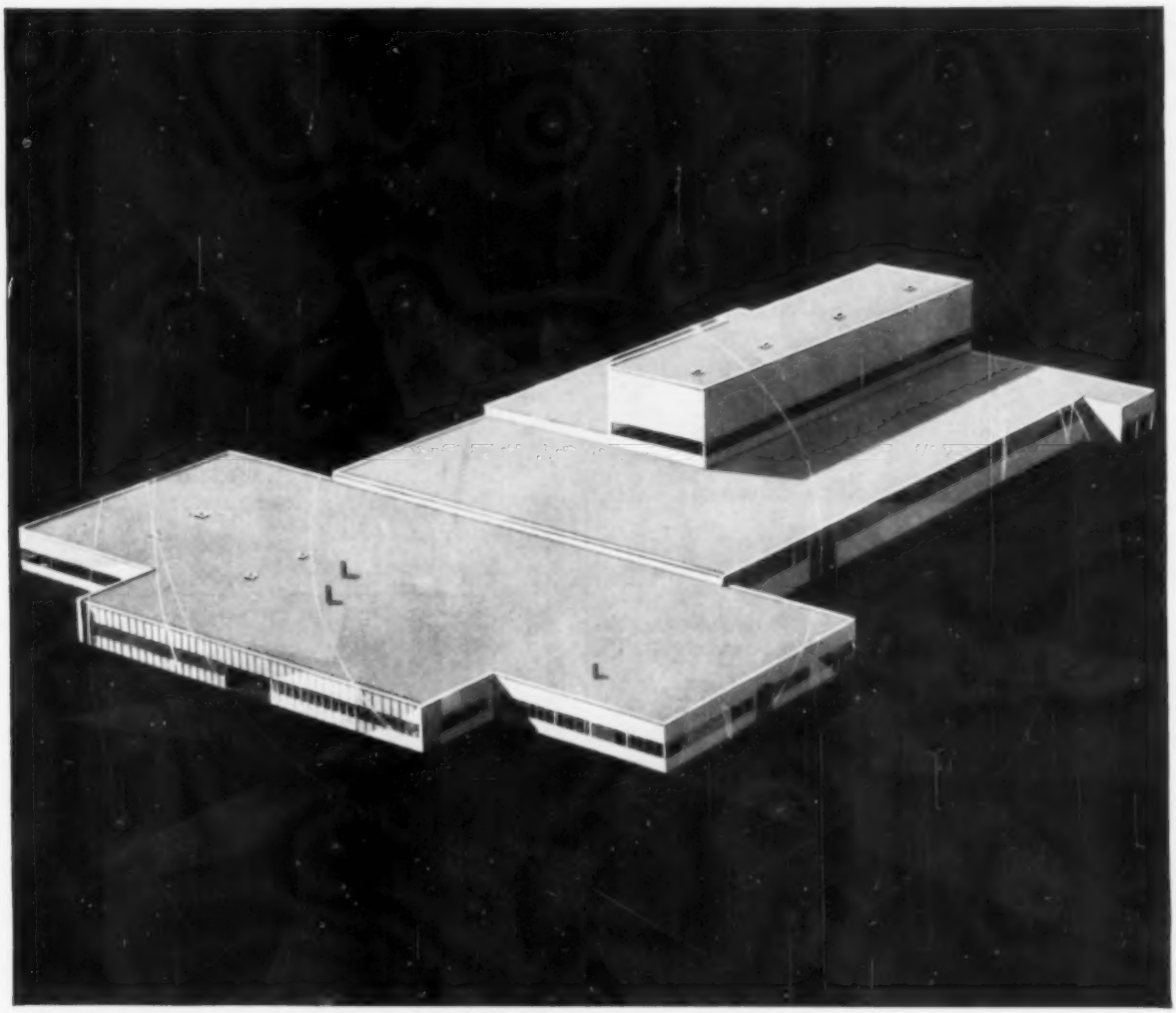
Here is a case where product quality and smooth, uninterrupted production are both dependent on extreme uniformity in the fine wire being used—extreme uniformity in diameter, finish and temper.

This super-critical wire is produced by the Worcester Wire Works Division of National-Standard. Because it does the best job by production comparison, it's naturally preferred. Keep this in mind and check with the Worcester Wire Works Division on your next need for fine wire if quality control is at all a factor. You'll get the finest of *service*, too!

NATIONAL NS NATIONAL-STANDARD Company **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *fine wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*

Metals Division of Kelsey-Hayes expands in New Hartford . . . to produce vacuum induction metals for all industry



Capacity: 1 Million Pounds Per Month

Our new facilities make it possible for all industry to obtain vacuum induction melted alloys on a production tonnage basis—ingot, billet, bar, sheet, strip and wire to specifications. *New areas of application, perhaps in your field, are opening up every day.* For information on the latest developments and technical brochure on new and improved alloys, write Metals Division, Kelsey-Hayes Company, New Hartford, New York.

U DI MET® ALLOYS

METALS DIVISION OF KELSEY-HAYES

SOME ALLOYS COVERED BY U.S. PATENT #2809110

®TRADE MARK REGISTERED

What are your requirements?

☐ Anti-galling characteristics combined with high corrosion-resistance?
Probable Solution:
WAUKESHA METAL 23* or 88*

☐ Homogeneous, free machining, corrosion-resistant castings?
Probable Solution:
Again WAUKESHA METAL 23* or 88*

☐ Heat resistant castings?
Answer:
Many formulations for specific requirements.

☐ Stainless steel (300-400 series) Ni-resist or special corrosion-resistant formulations?
Answer:
A completely separate foundry for this work.

☐ Pure nickel, monel, brass, bronze, everdur?
Solution:
Again, WAUKESHA has a second foundry devoted exclusively to casting these metals.

☐ Aluminum?
Answer:
A third foundry for aluminum only — as cast or heat-treated.

☐ Special research?
Answer:
WAUKESHA has one of the country's finest, most completely equipped Metallurgical Research Laboratories — at your command and without charge.

*So unusual and different are WAUKESHA Metals 23 and 88 that patents have been granted on both formulations.

Write us giving your specifications — or send us a print or pattern.

Waukesha
FOUNDRY COMPANY
5807 Lincoln Avenue • Waukesha, Wisconsin

CUT COSTS!

Blast Metal Away with ARCAIR!

Here's metal removal to beat anything you've ever seen before! Arcair Torch cuts, gouges, grooves, bevels or flushes off *any* metal . . . does it faster, cheaper, through a revolutionary combination of the electric arc and ordinary compressed air.

Inexpensive to install, economical to operate, easy to use—works with any standard arc welding unit.

WRITE TODAY FOR COMPLETE INFORMATION!

Arcair Metal Removal Torches
475 S. Mt. Pleasant St., LANCASTER, OHIO

BLUE M
CON-WATE PATENTS PENDING ®
Ultra-Temp
MECHANICAL CONVECTION
OVENS
NEW! ELECTRONIC CONTROL SYSTEM* ± 2°F. CONTROL
*patent pending

150 F. to 1200 F.
Horizontal Air Flow
WATTAGE CONTROL
ALLOY (18-8) INTERIOR

RESEARCH or PRODUCTION
ALUMINUM
MAGNESIUM
TITANIUM and Other Alloys

BLUE M NEW CONTROL SYSTEM* in conjunction with 3 step power selection, constant air weight, and greater air flow distribution provides an unequalled combination.

These ovens can be certified for Air Force Specifications MIL. H-6088A.

EXCELLENT UNIFORMITY
QUALITY CONSTRUCTION
Ready For Service

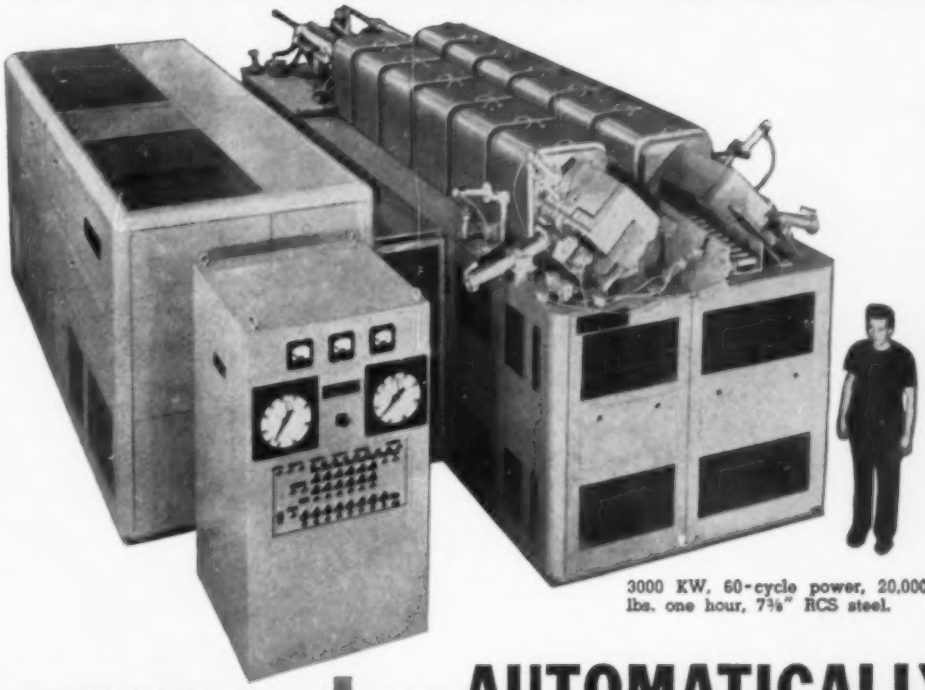
3 SIZES (1.6 to 5.8 cu. ft.)

Moderately priced.

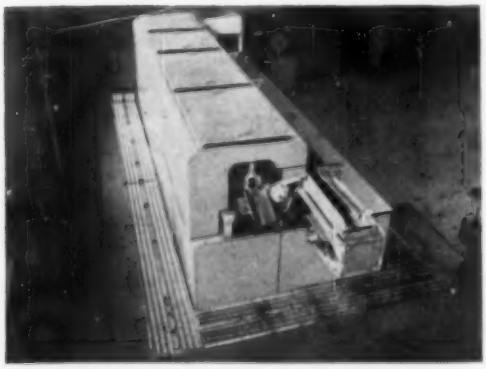
BLUE M ELECTRIC CO. BLUE ISLAND, ILL.
MANUFACTURERS AND DESIGNERS OF COMPLETE TEMPERATURE-CONTROLLED EQUIPMENT

INDUCTION FORGING HEATERS

THAT START STOP AND HOLD AUTOMATICALLY



3000 KW, 60-cycle power, 20,000 lbs. one hour, 7⅜" RCS steel.



Dual Frequency Forge Heater . . . 500 KW, 960 cycle; 500 KW, 60 cycle. 2"-4" RCS steel, 6000 lbs. per hour.

Dual Frequency Forge Heater . . . 900 KW, 60 cycles; 1000 KW, 3000 cycles. 4" RCS steel, 10,500 lbs. per hour.

These induction heaters for steel forging billets differ from any forge billet heaters ever built.

- They are empty at the start—using only two or three dummy billets.
- They have an automatic clean-out—heats are easily segregated.
- They hold at the proper temperature and have automatic voltage regulation.

The heaters keep pace with the press . . . no need of building up a stockpile of heated billets. Completely automatic, the "Magnethermics" eliminate guesswork and deliver a billet at the proper temperature every time.

Magnethermic's engineers have studied forge shop practice for a good many years. If you are considering a modernization program in your forge shop, write Magnethermic for recommendations.

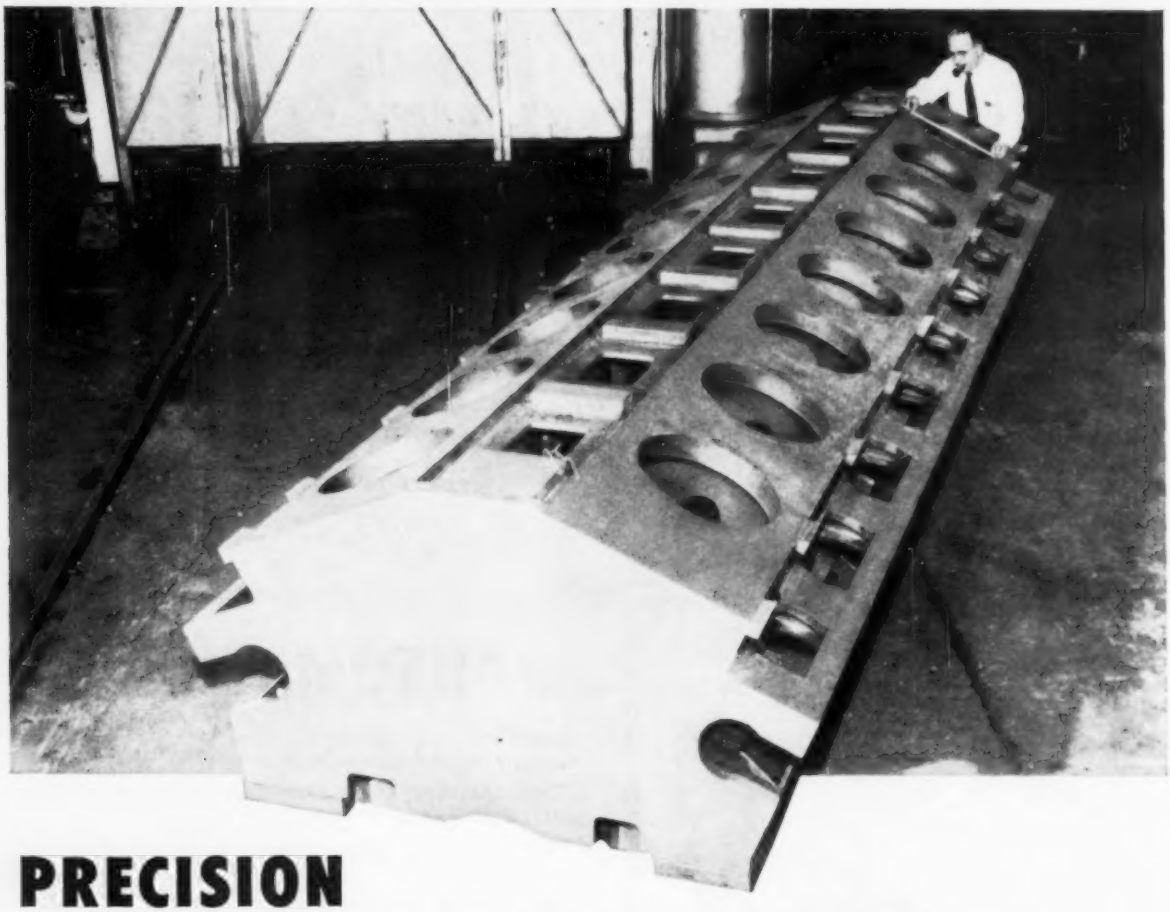
Movie Available on These Automatic Forging Heaters

16 mm, color, shows the complete cycle of operation. Write to Magnethermic and advise when you would like a showing.

MAGNETHERMIC®
CORPORATION
3990 SIMON RD. • YOUNGSTOWN 7, OHIO

SEE US AT THE METALS SHOW, BOOTH 940

STEEL-WELD FABRICATION . . .



PRECISION
in Production of Weldments of Great Strength!

The heavy weldment above is the frame for a sixteen-cylinder, 5000 H.P. Diesel Engine. It is typical of the precision parts entrusted to Mahon for fabrication by hundreds of manufacturers throughout the country.

When you consider Steel-Weld Fabricated components for processing machinery, machine tools, or other types of heavy mechanical equipment, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

Use WELDED STEEL for 100% Predictability and Greater Strength with Reduced Weight!

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

KENNAMETAL*

wear resistant • heat resistant

TUNGSTEN CARBIDES • TITANIUM CARBIDES

PRODUCT	PROPERTIES	TYPICAL APPLICATIONS
Kennametal (tungsten-base carbides)	YME of 60 to 90 million psi. Compressive strength higher than virtually all melted and cast or forged metals and alloys. Kennametal outwears steel up to 100 to 1. Impact strength in the range of hardened alloy steels of very much lower hardness and compressive strength. Thermal expansion about half that of steel. Compositions to withstand one or various combinations of destructive agents such as abrasion, corrosion, galling, impact, and erosion, or meet specific requirements as to stiffness, strength and weight.	Metalworking and mining tool cutting edges. Die inserts. Seal rings. Integrator discs. Needle valves and cones. Compressor liners. Pulverizing hammers. Abrasion resistant knives, blades, shears. Boring bars. Spray orifices. Balls and seats for oil well pump valves.
Kentanium* (titanium-base carbides)	Superior strength and abrasion resistance at temperatures 1800°F. and up . . . temperatures that rapidly destroy conventional carbides or high temperature cast alloys. Can be subjected continuously to operating temperatures up to 2200°F., and up to 5000°F. for short periods. Greater resistance to thermal shock than ceramics. Highest stiffness-to-weight ratio of any material . . . approximately ⅓ the weight of steel. YME up to 60 million psi.	Sensing elements for high temperature thermostatic controls. Spinning tools for hot metals. Flash-trimming tools. Turbine components. Balls for pump check valves. Nuclear reactor equipment. Rotary seal rings. Hot rod mill guide inserts. Anvils for spot welding. Balls for hot hardness testing.
Refractory Carbides	Low binder content. High melting point — 5000° F to 7000° F.	Crucibles. Acid resistant parts. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability: Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding — cobalt and X-ray medical equipment. Rotational parts — flywheels, governors, gyroscope components. Electrical contactors for high current heavy duty applications.
Niobium	Metal — 99.8% grade. Granules, arc melting electrodes, bar, strip, foil. Metal — 99.5% and 98.5% grades. Powders, granules, arc melting electrodes. Oxide — 99% and 99.5% grades. Fine powder.	Bars: Nominal size ½" x 2" x 19". Other sizes available. Strip, Foil: .001" to .100" thick, up to 4" wide. Powders: 20 to 80 mesh. Granules: ⅛" to 40 mesh.
Tantalum	Metal — 99.9% (capacitor) grade. Solid form — strip, bar, foil, wire. Metal — 99.5% grade. Granules. Metal Powder — 99.8% grade. Fine powder. Oxide — 99% grade. Fine powder.	Bars: Nominal size ½" x 2" x 19". Other sizes available. Strip, Foil: .001" to .100" thick, up to 4" wide. Wire: From .005" to .030". Granules: 20 mesh. Other sizes and grades available. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.
Kenspray (hard surfacing material)	Powder applied by hand or mechanically-held metal spraying equipment. May be successfully applied to irregular shapes or flat surfaces. Only thin coating required (from .010" to .090"). Conserves material, provides uniform surface. After spraying application, part is heated to fuse the hard surfacing deposit to its base. For close tolerances, part may then be ground with silicon carbide wheels.	Machine components and equipment for food, chemical, petro-chemical, other processing industries . . . Cams, valve seats, sleeves, shafts, dies, guides, jigs, process rolls, wear strips, valve plugs and bodies, grain mill hammers, pump parts, agricultural equipment.
Kenplate (hard surfacing material)	Factory assembled as small, hexagonal plates in a uniform mating pattern on flexible woven-glass backing. Plate thicknesses from .062" to .250" in two hex sizes. May be applied by standard epoxy bonding, silver soldering, conventional brazing.	Wear plates in processing equipment. Liners for ball mills, inclined chutes for abrasive materials. Centrifuge surfaces. Slide surfaces, guide rails for materials handling equipment.

FOR DETAILED INFORMATION send for:

1. **Characteristics of Kennametal** — 24-page outline of the company, its history, manufacturing methods and facilities. Plus a detailed description of Kennametal and Kentanium characteristics . . . physical and mechanical properties, with suggestions for design application.
2. **Kentanium** — 12-page description of physical characteristics and applications.
3. **Designing with Kennametal** — 42 pages of design ideas . . . problems and solutions in designing with carbides, fastening methods, typical applications.
4. **Tantalum Product Data Sheet** — Gives analyses, available forms and sizes.
5. **Columbium Product Data Sheet** — Gives analyses, available forms and sizes.

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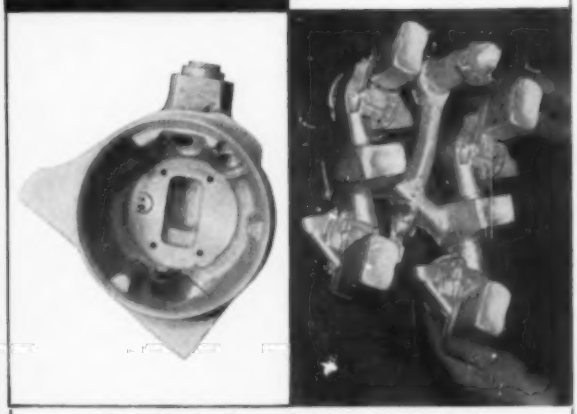

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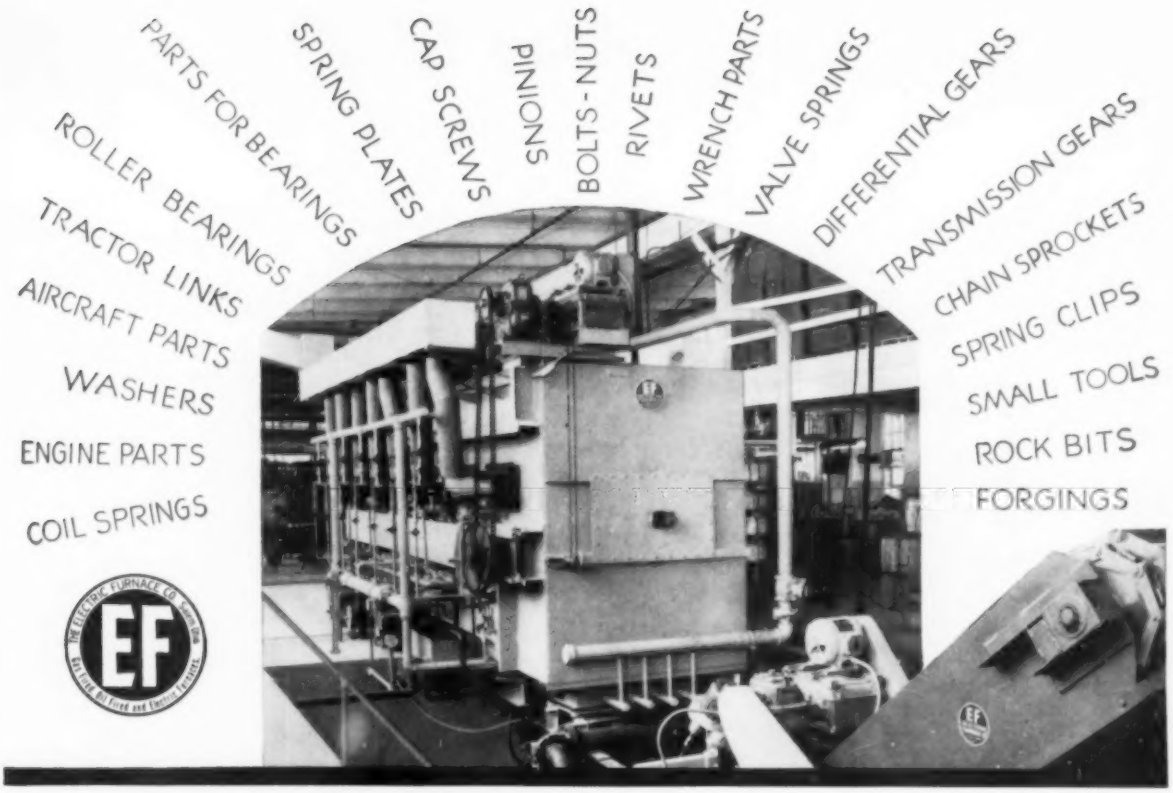

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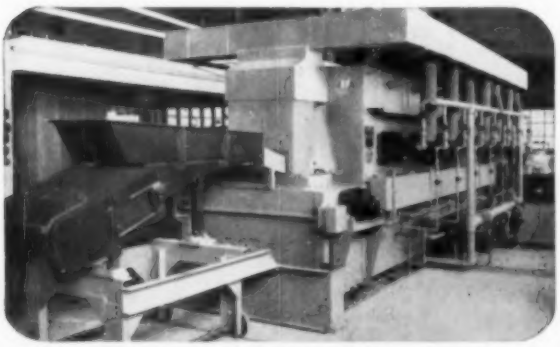

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